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Kilibarda et al.

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(54) **INVERTED CARRIER LIFT DEVICE SYSTEM AND METHOD**

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(73) Assignee: **Comau LLC**, Southfield, MI (US)

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(21) Appl. No.: **16/507,141**

(22) Filed: **Jul. 10, 2019**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**

B65G 13/02 (2006.01)
B65G 17/20 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***B65G 13/02*** (2013.01); ***B62D 65/18*** (2013.01); ***B65G 1/023*** (2013.01); ***B65G 1/0457*** (2013.01);

(Continued)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,493,005 A 1/1950 Williams
2,835,964 A 5/1958 Yarwood

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2718907 A1 9/2009
CA 2663307 A1 11/2009

(Continued)

OTHER PUBLICATIONS

International Preliminary Report of Patentability in corresponding application PCT/2014/064948, dated May 17, 2016.

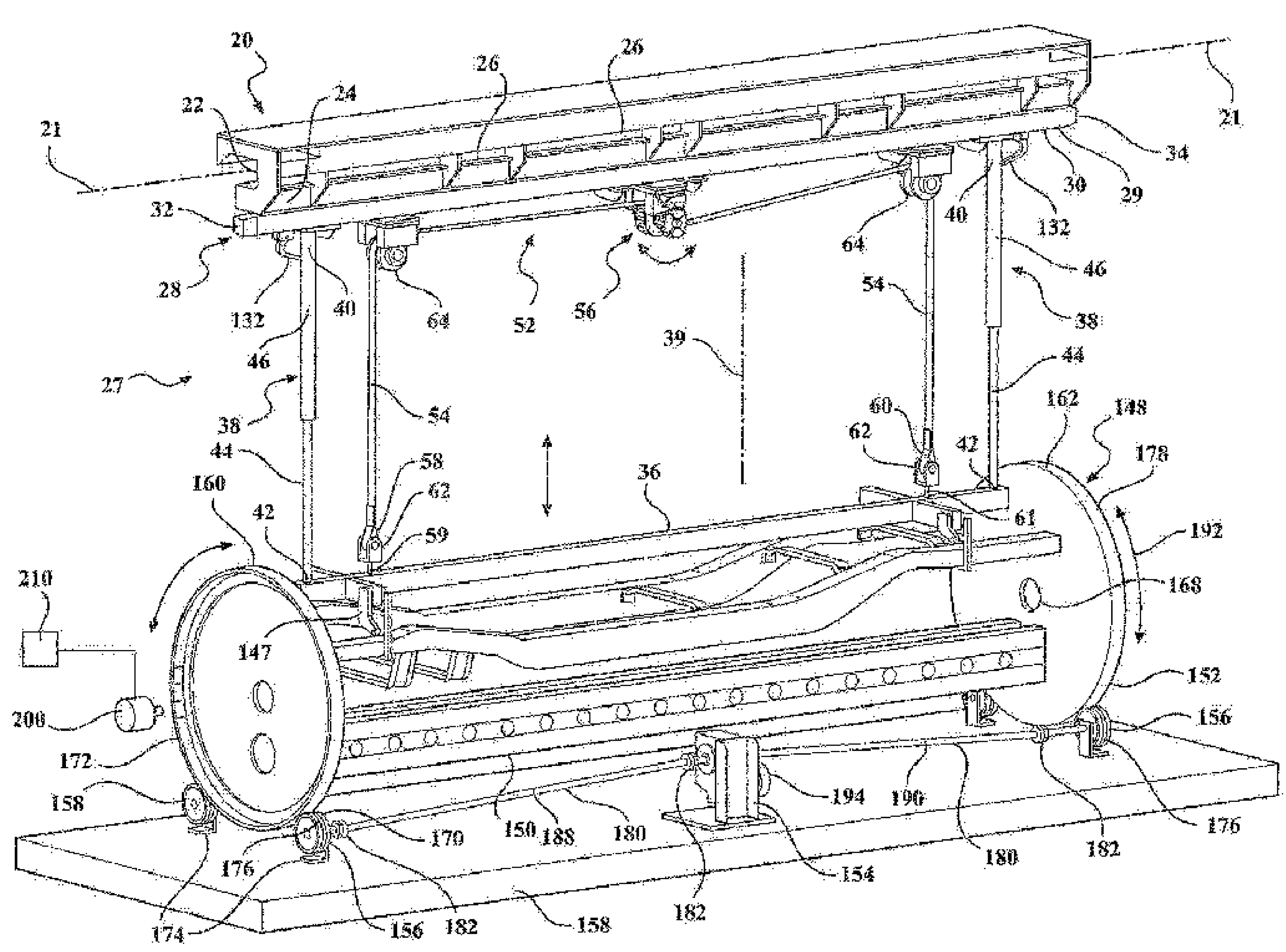
(Continued)

Primary Examiner — William R Harp
(74) *Attorney, Agent, or Firm* — Young Basile Hanlon & MacFarlane, P.C.

(57) **ABSTRACT**

An inverted carrier lift and method is disclosed. The inverted carrier lift includes a trolley movable along an overhead conveyor and a carrier for supporting a workpiece to undergo an assembly or manufacturing process. The carrier is movable relative to the trolley from a raised position to a lowered position by a motor engaged with a lifting mechanism on the trolley. On rotation of the motor, the carrier and supported workpiece is lowered or raised to position the workpiece in the workstation for processing. The workpiece may be disengaged by the carrier for support of the workpiece by one of many different fixtures depending on the processing. Following processing, the workpiece is re-engaged by the carrier, moved to a raised position and the trolley is transferred to a subsequent workstation.

14 Claims, 25 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 62/433,405, filed on Dec. 13, 2016, provisional application No. 62/332,598, filed on May 6, 2016.

(51) **Int. Cl.**

B65G 19/02	(2006.01)
B65G 47/61	(2006.01)
B65G 49/04	(2006.01)
B62D 65/18	(2006.01)
B65G 1/02	(2006.01)
B65G 1/04	(2006.01)
B65G 1/12	(2006.01)
B65G 1/14	(2006.01)
B65G 1/16	(2006.01)

(52) **U.S. Cl.**

CPC ***B65G 1/12*** (2013.01); ***B65G 1/14*** (2013.01); ***B65G 1/16*** (2013.01); ***B65G 17/20*** (2013.01); ***B65G 19/025*** (2013.01); ***B65G 47/61*** (2013.01); ***B65G 49/0454*** (2013.01); ***B65G 49/0463*** (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,444,802 A * 5/1969 Barton B65G 49/0459 454/63
3,854,889 A 12/1974 Lemelson
4,162,387 A 7/1979 De Candia
4,232,370 A 11/1980 Tapley
4,273,242 A * 6/1981 Schaper B66C 13/06 212/273
4,328,422 A 5/1982 Loomer
4,344,221 A 8/1982 Pagani
4,369,563 A 1/1983 Williamson
4,400,607 A 8/1983 Wakou et al.
4,442,335 A 4/1984 Rossi
4,456,810 A 6/1984 Schumacher et al.
4,530,056 A 7/1985 MacKinnon et al.
4,600,136 A 7/1986 Sciaky et al.
4,606,488 A 8/1986 Yanagisawa
4,659,895 A 4/1987 Di Rosa
4,667,866 A 5/1987 Tobita et al.
4,679,297 A 7/1987 Hansen, Jr. et al.
4,732,224 A * 3/1988 Deeter E21C 25/58 175/85
4,734,979 A 4/1988 Sakamoto et al.
4,736,515 A 4/1988 Catena
4,738,387 A 4/1988 Jaufmann et al.
4,774,757 A 10/1988 Sakamoto et al.
4,779,787 A 10/1988 Naruse et al.
4,795,075 A 1/1989 Pigott et al.
4,800,249 A 1/1989 Di Rosa
4,815,190 A 3/1989 Haba, Jr. et al.
4,872,419 A 10/1989 Blankemeyer et al.
4,885,836 A 12/1989 Bonomi et al.
4,896,014 A 1/1990 Sakai et al.
4,928,383 A 5/1990 Kaczmarek et al.
4,967,947 A 11/1990 Sarh
5,011,068 A 4/1991 Stoutenburg et al.
5,123,148 A 6/1992 Ikeda et al.
5,152,050 A 10/1992 Kaczmarek et al.
5,177,862 A * 1/1993 Speece B23P 21/004 29/430
5,199,156 A 4/1993 Rossi
5,285,604 A 2/1994 Carlin
5,301,411 A 4/1994 Fujiwara et al.
5,319,840 A 6/1994 Yamamoto et al.
5,347,700 A 9/1994 Tominaga et al.
5,397,047 A 3/1995 Zampini
5,427,300 A 6/1995 Quagline
5,433,783 A * 7/1995 Ichinose B65G 49/0459 118/416
5,531,830 A 7/1996 Ichinose et al.
5,538,382 A 7/1996 Hasegawa et al.
5,560,535 A 10/1996 Miller et al.
5,577,595 A 11/1996 Pollock et al.
5,697,752 A 12/1997 Dugas et al.
5,779,609 A 7/1998 Cullen et al.
5,853,215 A 12/1998 Lowery
5,864,991 A 2/1999 Burns
5,896,637 A 4/1999 Sarh
5,902,496 A 5/1999 Alborante
5,940,961 A 8/1999 Parete
5,943,768 A 8/1999 Ray
6,008,471 A 12/1999 Alborante
6,059,169 A 5/2000 Nihei et al.
6,065,200 A 5/2000 Negre
6,098,268 A 8/2000 Negre et al.
6,132,509 A 10/2000 Kuschnereit
6,138,889 A 10/2000 Campani et al.
6,142,725 A 11/2000 Crorey
6,170,732 B1 1/2001 Vogt et al.
6,193,142 B1 2/2001 Segawa et al.
6,250,533 B1 6/2001 Otterbein et al.
6,253,504 B1 7/2001 Cohen et al.
6,324,880 B1 12/2001 Nakamura
6,325,435 B1 12/2001 Dubuc
6,336,582 B1 1/2002 Kato et al.
6,349,237 B1 2/2002 Koren et al.
6,457,231 B1 10/2002 Carter et al.
6,467,675 B1 10/2002 Ozaku et al.
6,513,231 B1 2/2003 Hafenrichter et al.
6,516,234 B2 2/2003 Kamiguchi et al.
6,557,690 B2 5/2003 Oldford et al.
6,564,440 B2 5/2003 Oldford et al.
6,651,392 B2 11/2003 Ritzal
6,688,048 B2 2/2004 Staschik
6,705,001 B2 3/2004 How et al.
6,705,523 B1 3/2004 Stamm et al.
6,712,230 B2 3/2004 Lopez Alba
6,719,122 B2 4/2004 Oldford et al.
6,744,436 B1 6/2004 Chirieleison, Jr. et al.
6,799,672 B2 10/2004 Wood
6,799,673 B2 10/2004 Kilabarda
6,813,539 B2 11/2004 Morimoto et al.
6,857,529 B2 2/2005 Lopez Alba
6,916,375 B2 7/2005 Molnar et al.
6,948,227 B2 9/2005 Kilibarda et al.
6,966,427 B2 11/2005 Kilibarda
6,990,715 B2 1/2006 Liu et al.
6,991,064 B2 1/2006 Ehrenleitner
7,108,189 B2 9/2006 Kilibarda
7,232,027 B2 6/2007 Kilibarda
7,331,439 B2 2/2008 Degain et al.
7,356,378 B1 4/2008 Huang et al.
7,357,376 B2 * 4/2008 Assmann B66C 13/06 254/337
7,490,710 B1 2/2009 Weskamp et al.
7,546,942 B2 6/2009 Monti et al.
7,845,121 B2 12/2010 Wobben
8,097,451 B2 1/2012 Gaalswyk
8,127,687 B2 3/2012 Spangler et al.
8,201,723 B2 6/2012 Kilibarda
8,308,048 B2 11/2012 Kilibarda
8,360,225 B2 1/2013 Spangler et al.
8,474,132 B2 7/2013 Li et al.
8,474,683 B2 7/2013 Kilibarda
8,561,780 B2 10/2013 Albeck et al.
8,713,780 B2 5/2014 Kilibarda
8,733,617 B2 5/2014 Kilibarda
8,789,269 B2 7/2014 Kilibarda et al.
8,869,370 B2 10/2014 Kilibarda
9,513,625 B2 12/2016 Kilibarda
9,802,766 B2 10/2017 Ookada et al.
10,384,873 B2 * 8/2019 Kilibarda B65G 17/20
2002/0087226 A1 7/2002 Boudreau
2002/0103569 A1 8/2002 Mazur
2002/0129566 A1 9/2002 Piccolo et al.
2002/0135116 A1 9/2002 Dugas et al.
2002/0162209 A1 11/2002 Hosono et al.
2002/0166842 A1 11/2002 Grebenisan

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0037432	A1	2/2003	McNamara
2003/0057256	A1	3/2003	Nakamura et al.
2003/0085192	A1	5/2003	Lopez Alba
2003/0115746	A1	6/2003	Saito et al.
2003/0175429	A1	9/2003	Molnar et al.
2003/0188952	A1	10/2003	Oldford et al.
2003/0189085	A1	10/2003	Kilibarda et al.
2004/0002788	A1	1/2004	Morimoto et al.
2004/0020974	A1	2/2004	Becker et al.
2004/0055129	A1	3/2004	Ghuman
2004/0149692	A1	8/2004	Masanori
2004/0216983	A1	11/2004	Oldford et al.
2004/0221438	A1	11/2004	Savoy et al.
2004/0258513	A1	12/2004	Cooke
2005/0008469	A1	1/2005	Jung
2005/0025612	A1	2/2005	Ehrenleitner
2005/0035175	A1	2/2005	Nakamura et al.
2005/0044700	A1	3/2005	Ghuman et al.
2005/0120536	A1	6/2005	Kilibarda et al.
2005/0153075	A1	7/2005	Molnar et al.
2005/0189399	A1	9/2005	Kilibarda
2005/0230374	A1	10/2005	Rapp et al.
2005/0236461	A1	10/2005	Kilibarda et al.
2005/0269382	A1	12/2005	Caputo et al.
2006/0157533	A1	7/2006	Onoue et al.
2006/0231371	A1	10/2006	Moliere et al.
2006/0288577	A1	12/2006	Bormuth
2007/0087924	A1	4/2007	Krosta et al.
2007/0164009	A1	7/2007	Hesse
2007/0175869	A1	8/2007	Auger et al.
2007/0215579	A1	9/2007	Auger
2007/0258797	A1	11/2007	Gordon et al.
2008/0022609	A1	1/2008	Franco et al.
2008/0061110	A1	3/2008	Monti et al.
2008/0084013	A1	4/2008	Kilibarda
2008/0104815	A1	5/2008	Kussmaul
2008/0105733	A1	5/2008	Monti et al.
2008/0116247	A1	5/2008	Kilibarda
2008/0131255	A1	6/2008	Hessler et al.
2008/0148546	A1	6/2008	Monti et al.
2008/0178537	A1	7/2008	Spangler et al.
2008/0181753	A1	7/2008	Bastian et al.
2008/0223692	A1	9/2008	Tanahashi
2008/0295335	A1	12/2008	Kilibarda et al.
2009/0056116	A1	3/2009	Presley et al.
2009/0078741	A1	3/2009	Sata et al.
2009/0118858	A1	5/2009	Wallace et al.
2009/0234488	A1	9/2009	Kilibarda
2009/0277747	A1	11/2009	Spangler et al.
2009/0277748	A1	11/2009	Spangler et al.
2009/0277754	A1	11/2009	Spangler et al.
2009/0277755	A1	11/2009	Spangler et al.
2009/0279992	A1	11/2009	Spangler et al.
2009/0285666	A1	11/2009	Kilibarda
2009/0300998	A1	12/2009	Ablett
2010/0136883	A1	6/2010	Call et al.
2010/0180711	A1	7/2010	Kilibarda et al.
2010/0241260	A1	9/2010	Kilibarda et al.
2010/0301099	A1	12/2010	Sata et al.
2010/0326832	A1	12/2010	Albeck et al.
2011/0017132	A1	1/2011	Robbin
2011/0047788	A1	3/2011	Immekus et al.
2011/0047791	A1	3/2011	Ferenczi et al.
2011/0138601	A1	6/2011	Kilibarda
2011/0192007	A1	8/2011	Kilibarda
2011/0252719	A1	10/2011	Wallance
2012/0005968	A1	1/2012	Patino
2012/0222277	A1	9/2012	Spangler et al.
2012/0274000	A1	11/2012	Gaiser
2012/0304446	A1	12/2012	Kilibarda
2013/0026002	A1	1/2013	Spangler
2013/0035783	A1	2/2013	Scheuerman et al.
2013/0109291	A1	5/2013	Holtz et al.
2014/0217155	A1	8/2014	Kilibarda
2014/0224621	A1	8/2014	Monti et al.
2015/0128719	A1	5/2015	Kilibarda

FOREIGN PATENT DOCUMENTS

CA	2659143	A1	4/2010
CA	2904751	A1	4/2010
CA	2904752	A1	4/2010
CA	2786113	A1	7/2011
CN	101579792	A	11/2009
CN	101722421	A	6/2010
CN	102706746	A	10/2012
CN	103649857	A	3/2014
DE	19806963	A1	10/1998
DE	20012052	U1	10/2000
DE	19940992	A1	3/2001
DE	102004057664	A1	6/2006
DE	102005062691	A1	7/2007
DE	202007005034	U1	8/2008
EP	201262	A1	11/1986
EP	0232999	A2	8/1987
EP	0261297	A1	3/1988
EP	0446518	A1	9/1991
EP	574779	A1	12/1993
EP	1298043	A2	4/2003
EP	1302415	A1	4/2003
EP	1362663	A2	11/2003
EP	1403176	A2	3/2004
EP	1426275	A1	6/2004
EP	2100804	A1	9/2009
EP	2119532	A1	11/2009
EP	2332689	A1	6/2011
EP	2505299	A1	10/2012
EP	2585656	A2	5/2013
EP	2715465	A1	4/2014
GB	2250723	A	6/1992
GB	2271651	A	4/1994
JP	S6340683	A	2/1988
JP	H0740059	A	2/1995
JP	10101222		4/1998
JP	H11104848	A	4/1999
JP	2005205431	A	8/2005
JP	2011121089	A	6/2011
WO	8603153	A1	6/1986
WO	0068117	A1	11/2000
WO	2006109246	A1	10/2006
WO	2007077056	A1	7/2007
WO	2011085175	A2	7/2011
WO	2011162930	A1	12/2011
WO	2012166775	A1	12/2012

OTHER PUBLICATIONS

International Search Report and Written Opinion of the International Searching Authority dated Oct. 9, 2012 from the corresponding International Application No. PCT/US2012/039952.

International Search Report and Written Opinion of the International Searching Authority dated Aug. 29, 2011 from the corresponding International Application No. PCT/US2011/039097.

FMC; Automated Fork lifts and Material Handling Lifts—Forked Automated Guided Vehicles; http://www.fmcsgvs.com/content/products/forked.sub.—vehicles.htm;p. 1., printed Mar. 26, 2008.

FMC; SGV (Self Guided Vehicles)—Automated Guided Vehicle Systems; http://www.fmcsgvs.com/content/products/sgv.htm, p. 1, printed Mar. 26, 2008.

FMC; Automated Material Handling Systems & Equipment for Material Movement: AGV Applications; http://www.fmcsgvs.com/content/sales/applications.htm; pp. 1-2., printed Mar. 26, 2008.

FMC; Layout Wizard AGV Configuration Software; http://fmcsgvs.com/content/products/wizard.htm; p. 1., printed Mar. 26, 2008.

FMC; Laser Navigation Controls; http://www.fmcsgvs.com/content/products/nav.htm; pp. 1-2., printed Mar. 26, 2008.

European Search Report dated Jul. 13, 2009 from the corresponding European Application No. 09151980.1-1523.

FMC; AGV System Controls; http://www.fmcsgvs.com/content/products/system.htm; p. 1., printed Mar. 26, 2008.

(56) **References Cited**

OTHER PUBLICATIONS

European Search Report dated Apr. 19, 2011 from the corresponding European Patent Application No. 11152656.2-2302.

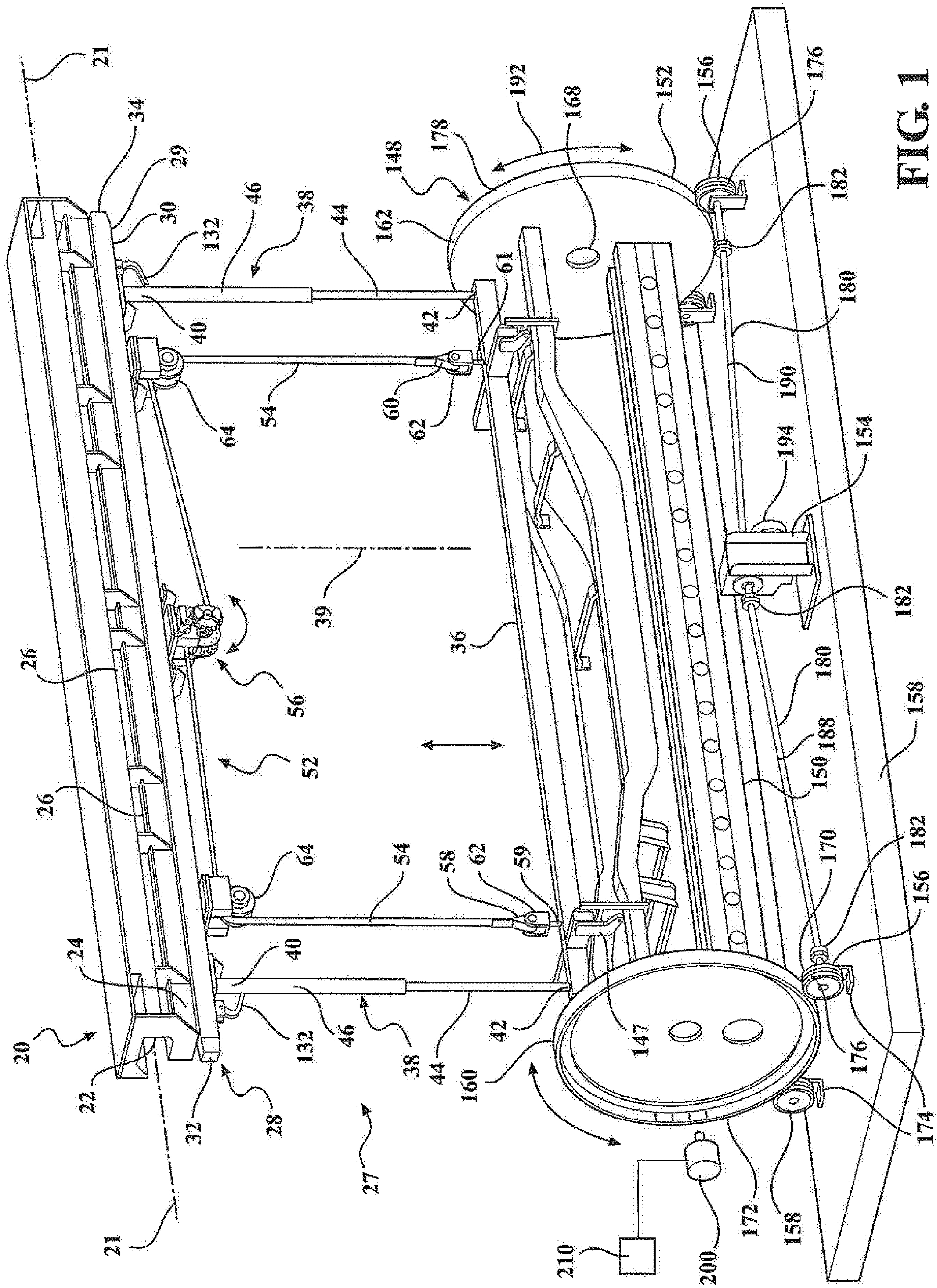
European Search Report dated Aug. 28, 2009 from the corresponding European Patent Application No. 09158794.9-2302.

Mats Jackson and Abedullah Zaman, Factory-In-a-Box-Mobile Production Capacity of Demand, International Journal of Modern Engineering vol. 8, No. 1 Fall2007.

Notification of Transmittal, the International Search Report and the Written Opinion of the International Searching Authority dated Jan. 28, 2013, from the corresponding International Application No. PCT/US2011/020486 filed Jan. 7, 2011.

International Search Report in related matter PCT/US2015/065588, dated May 19, 2016, 25 pages.

* cited by examiner



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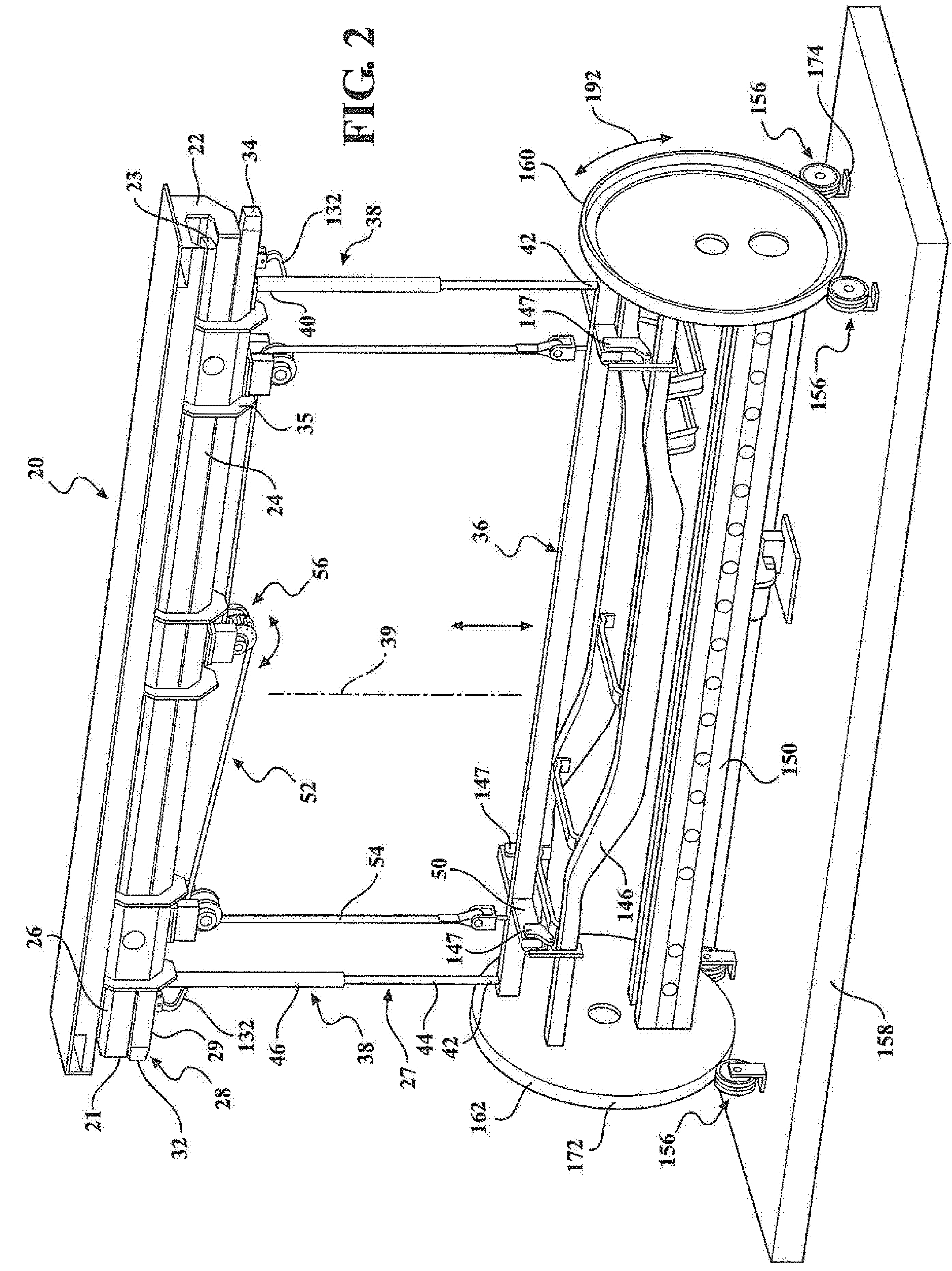
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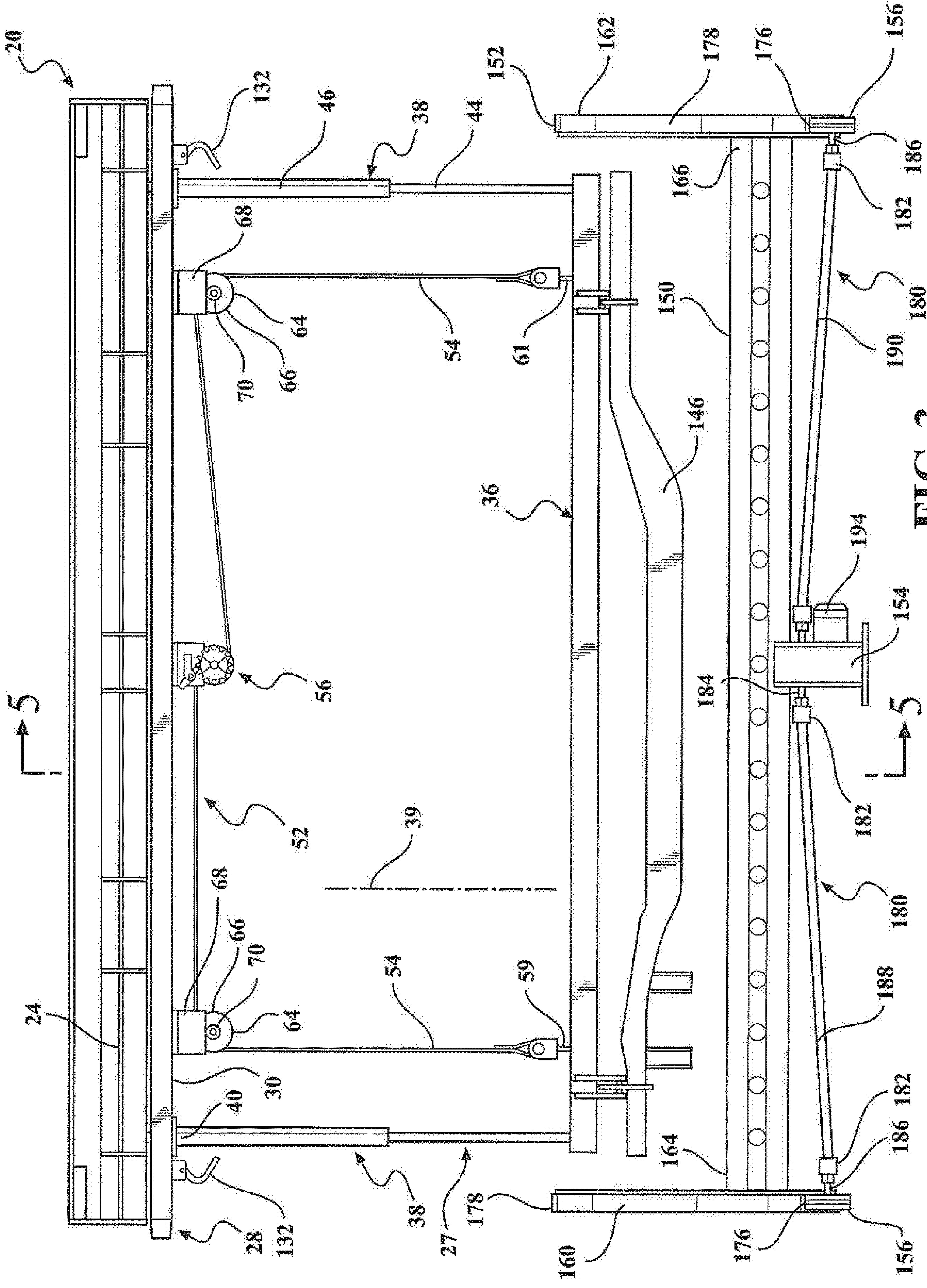
FIG. 2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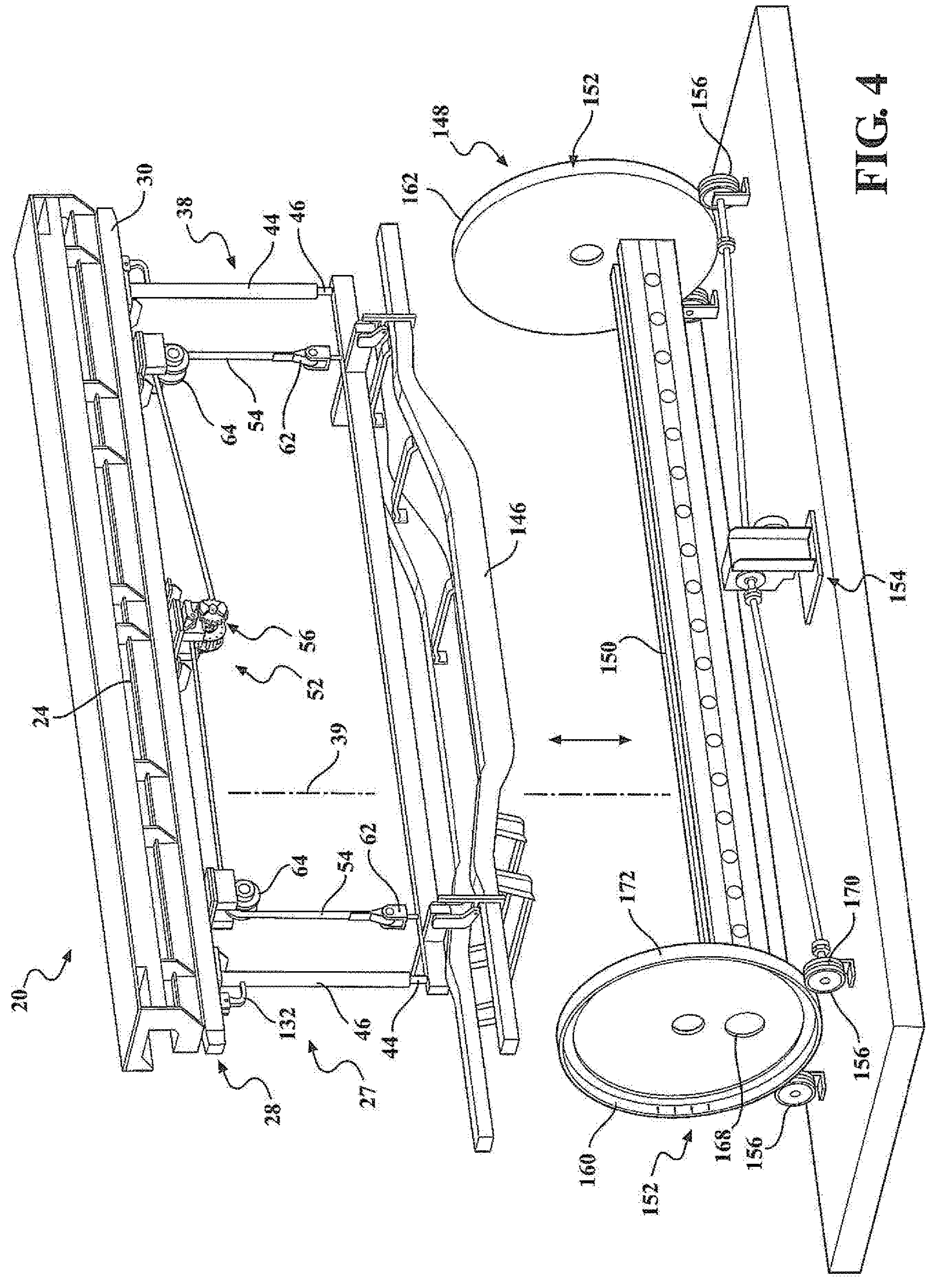
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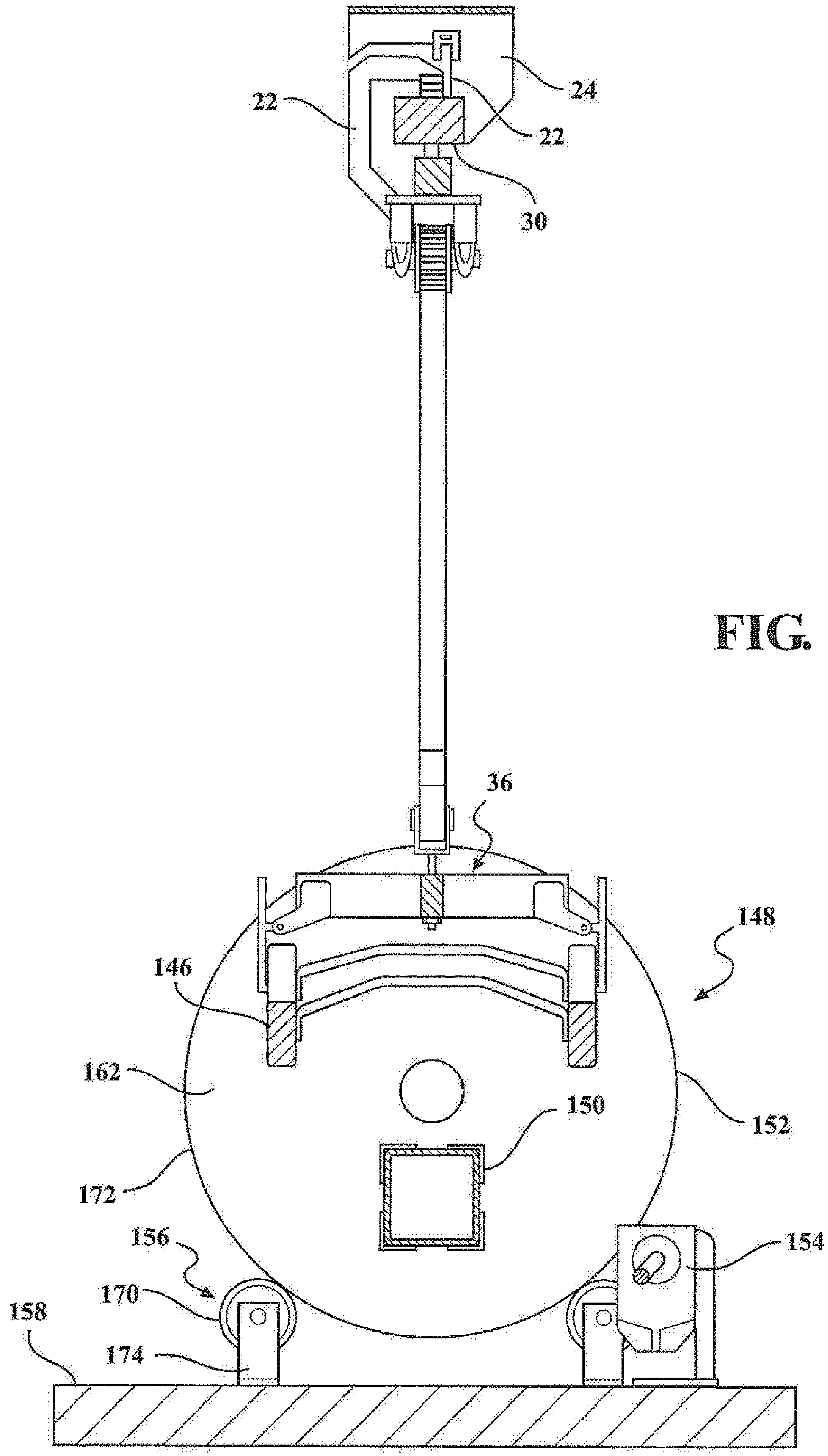
FIG. 4



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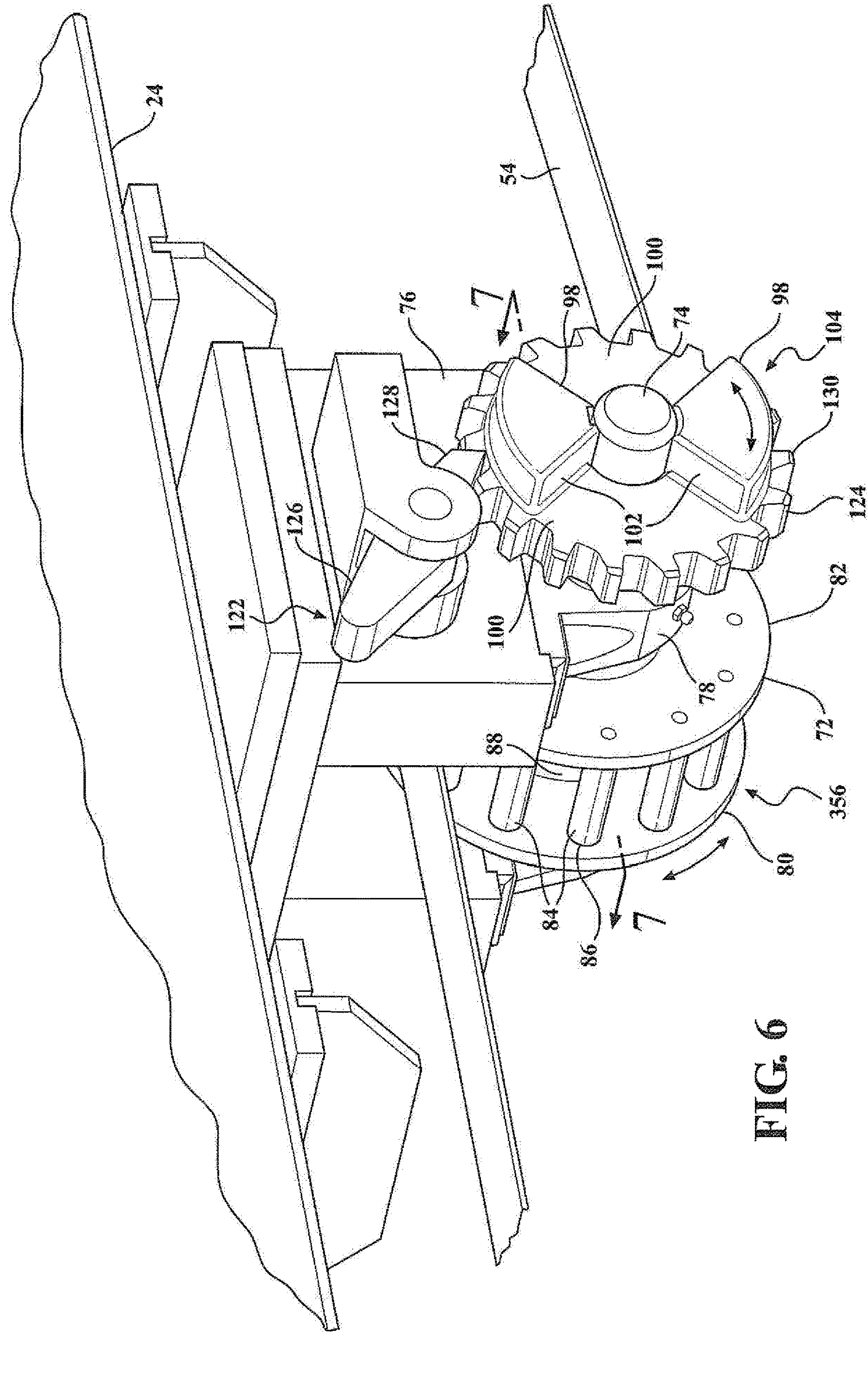
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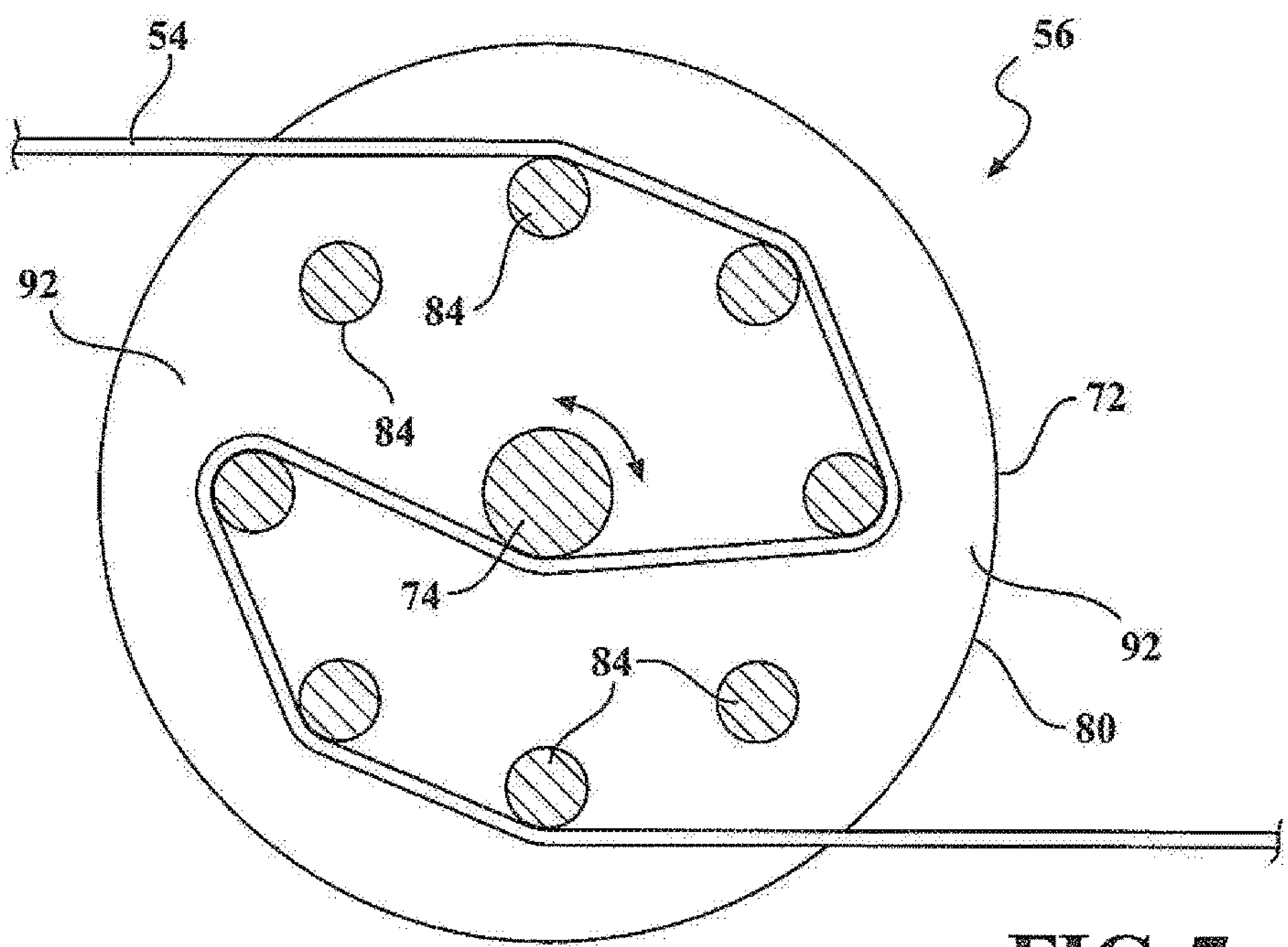
FIG. 6



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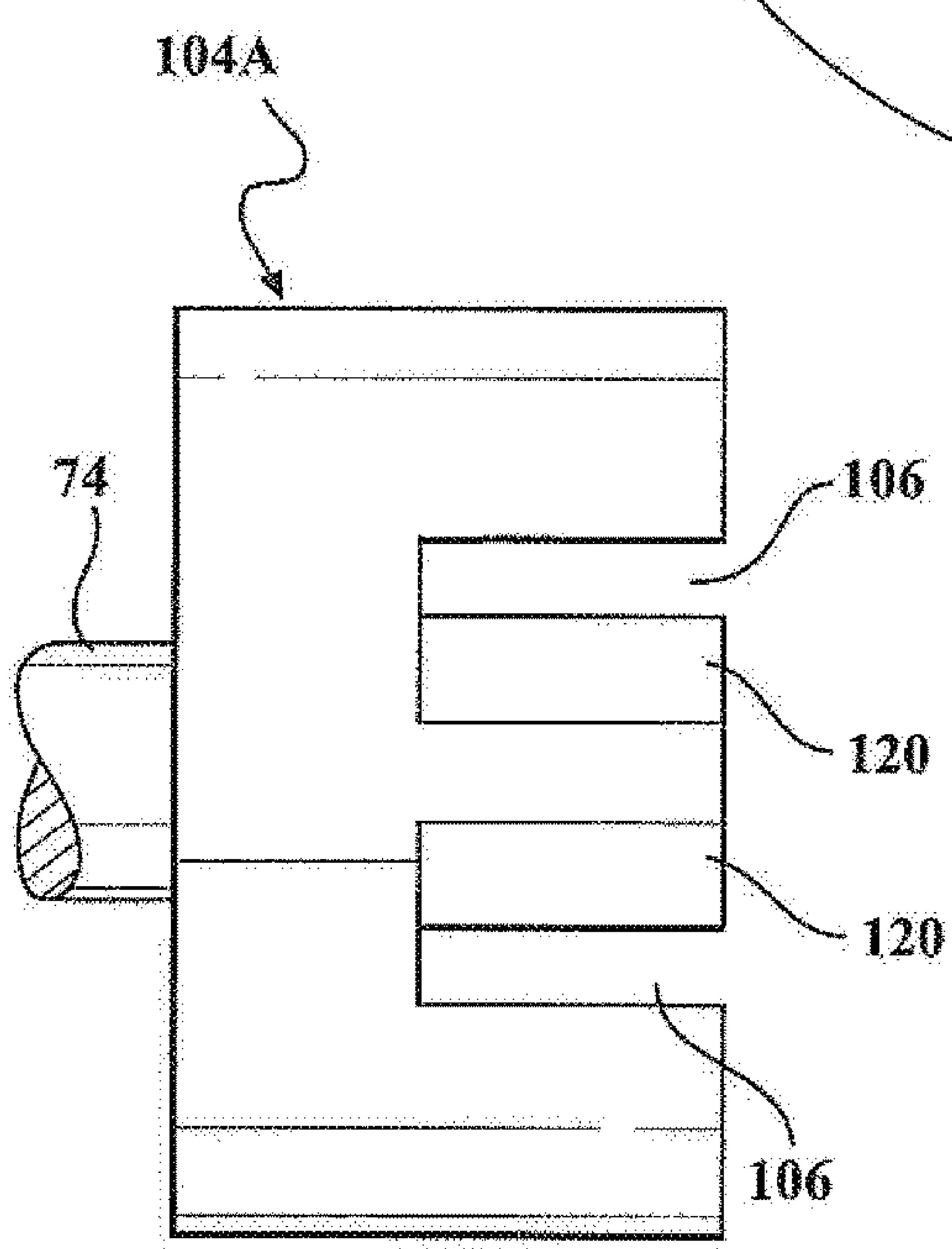

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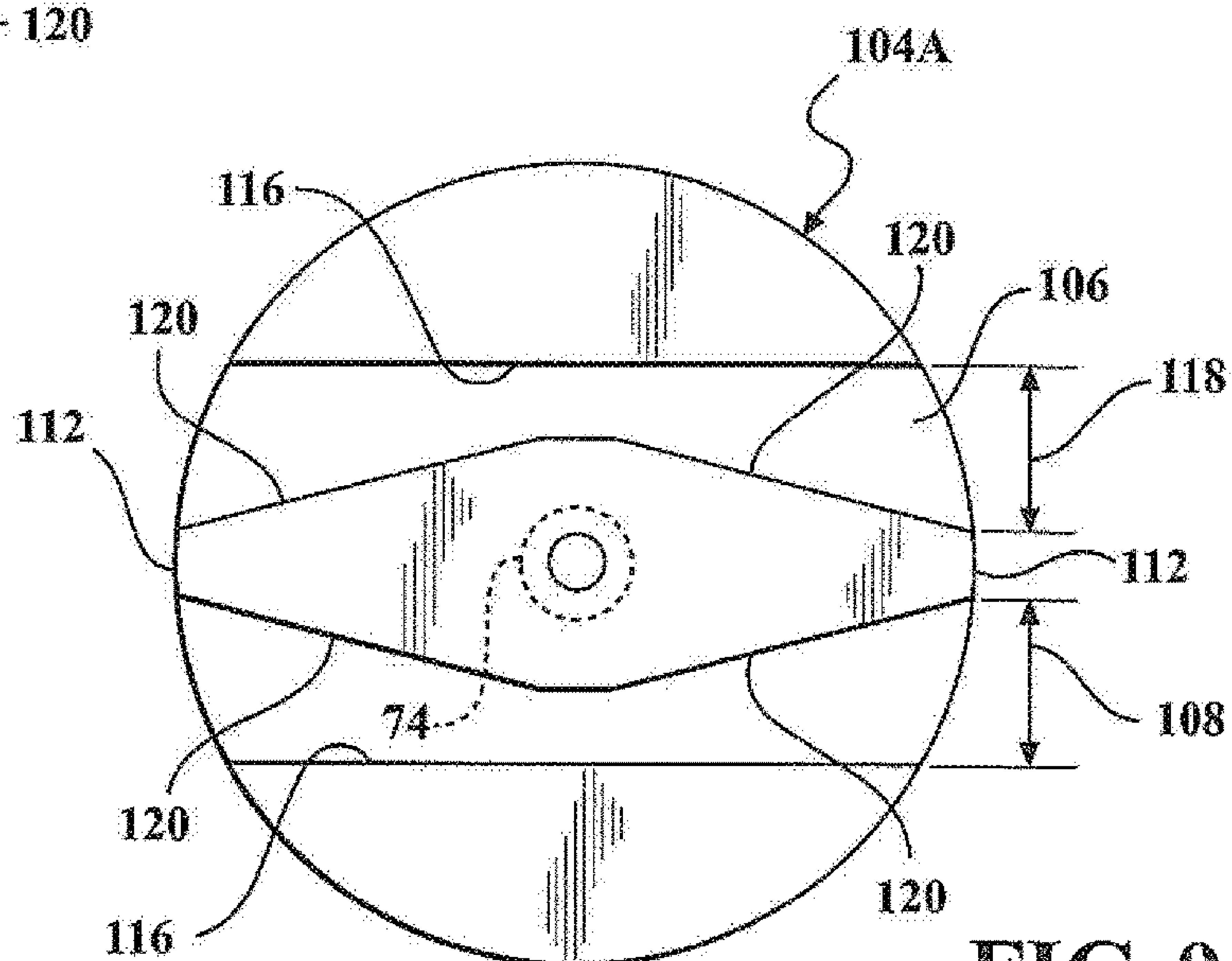

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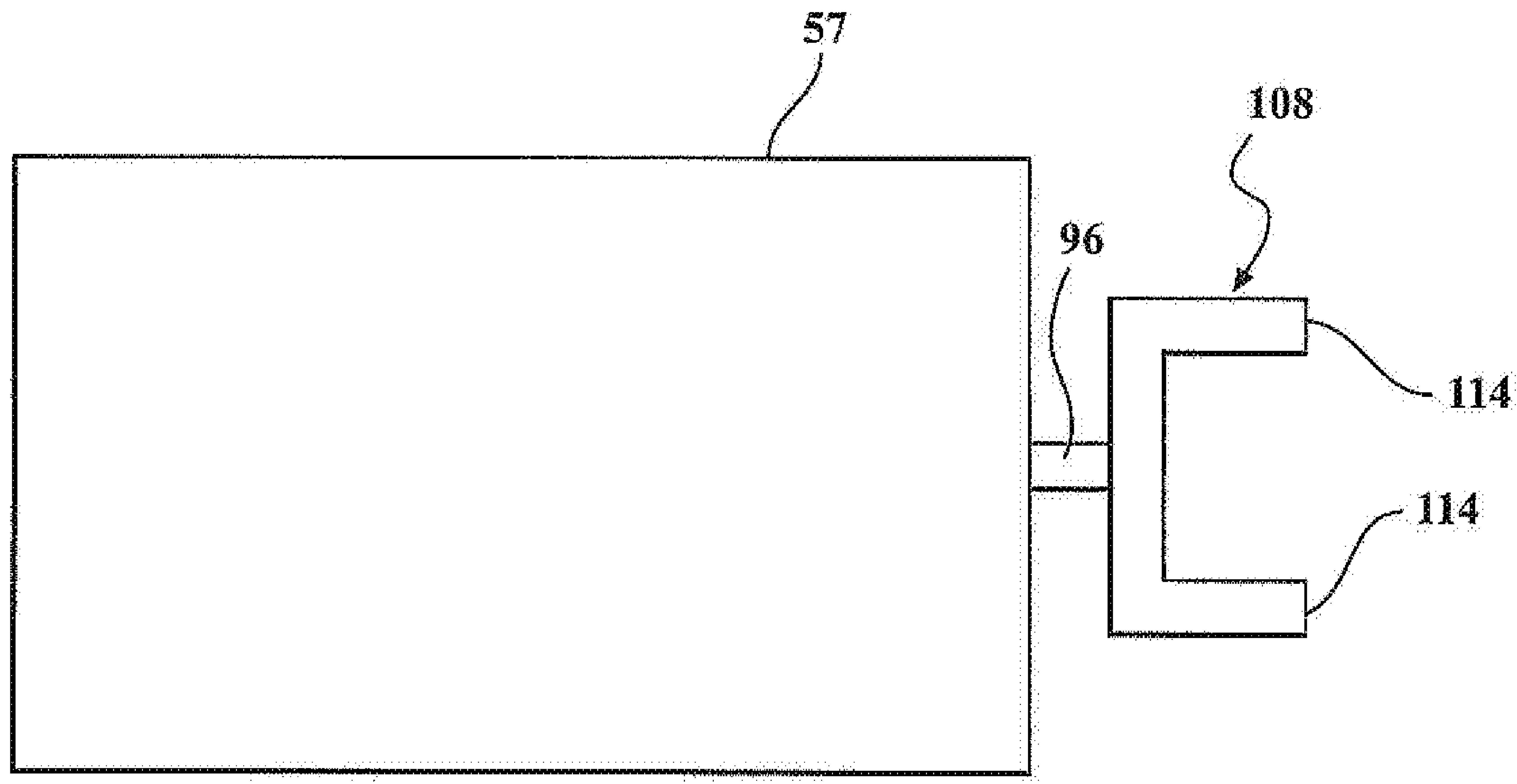

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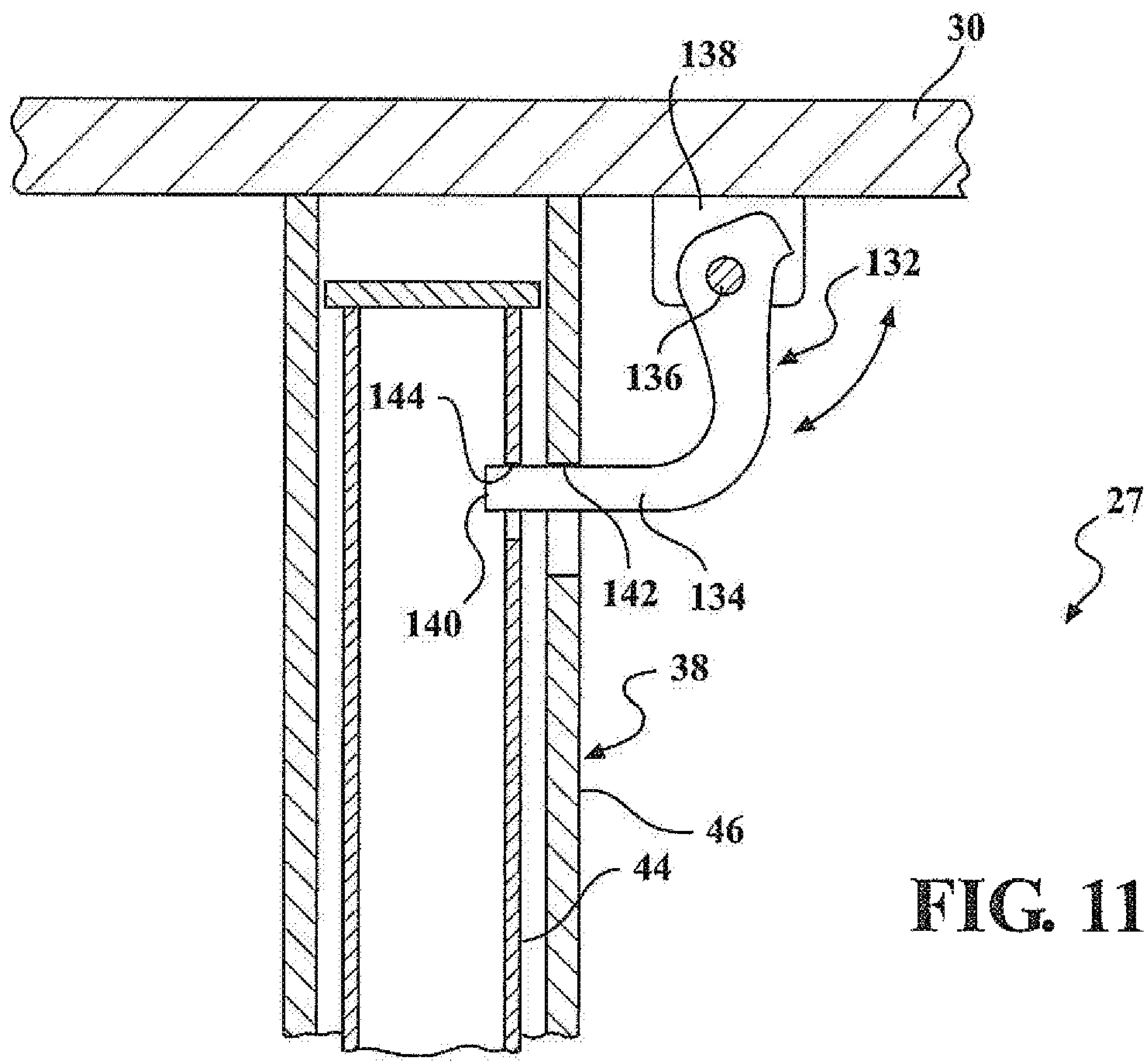

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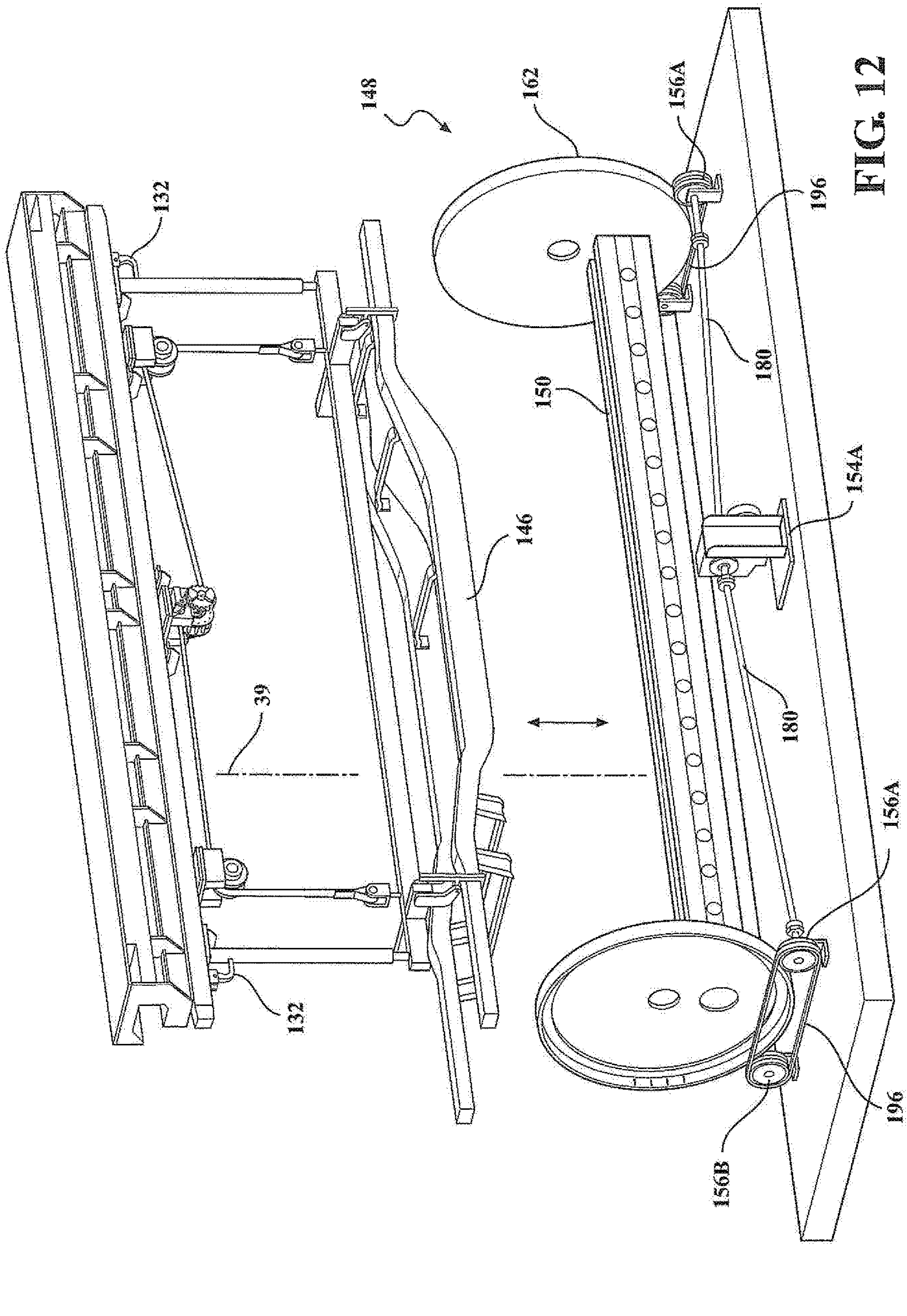

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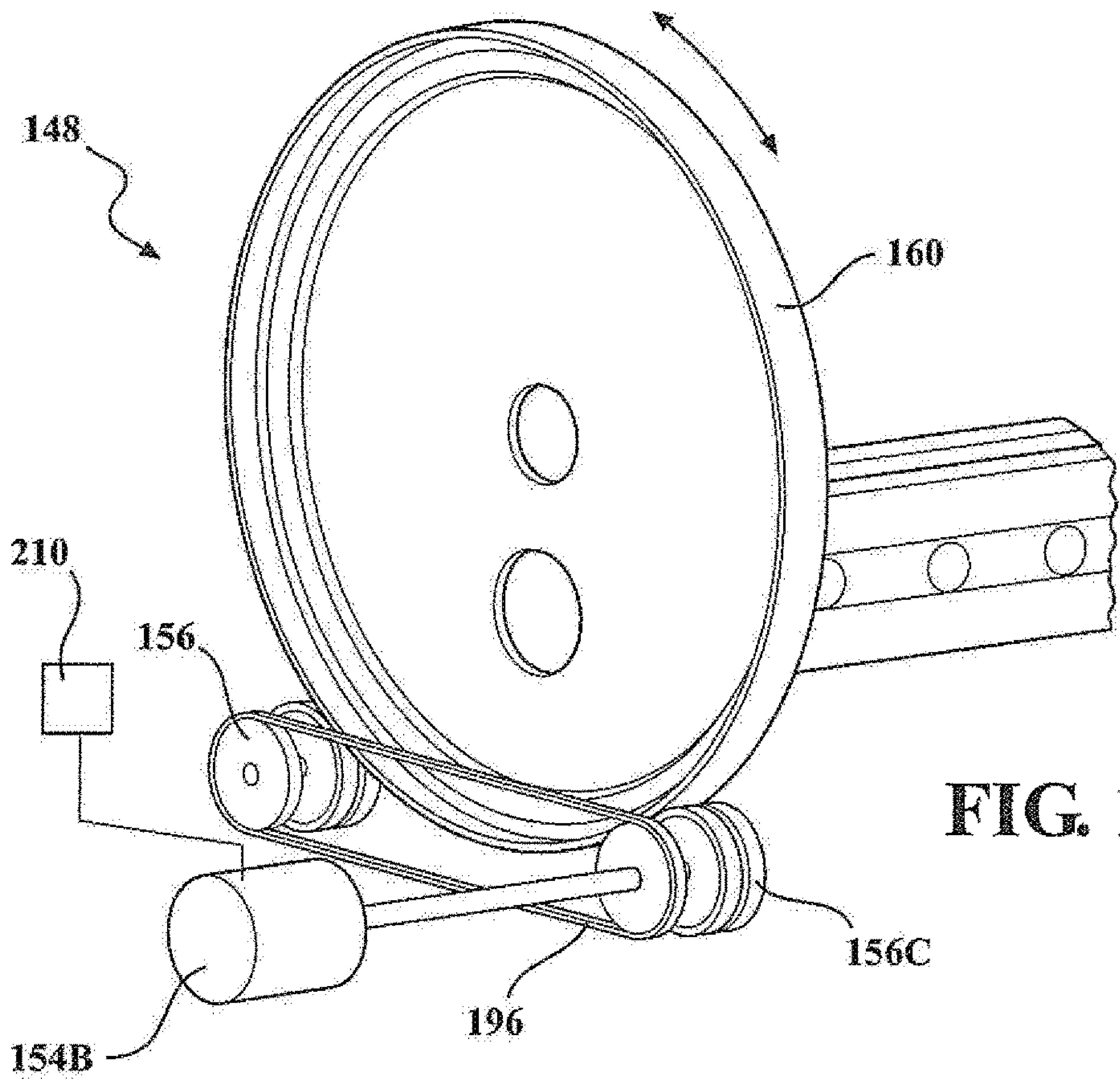
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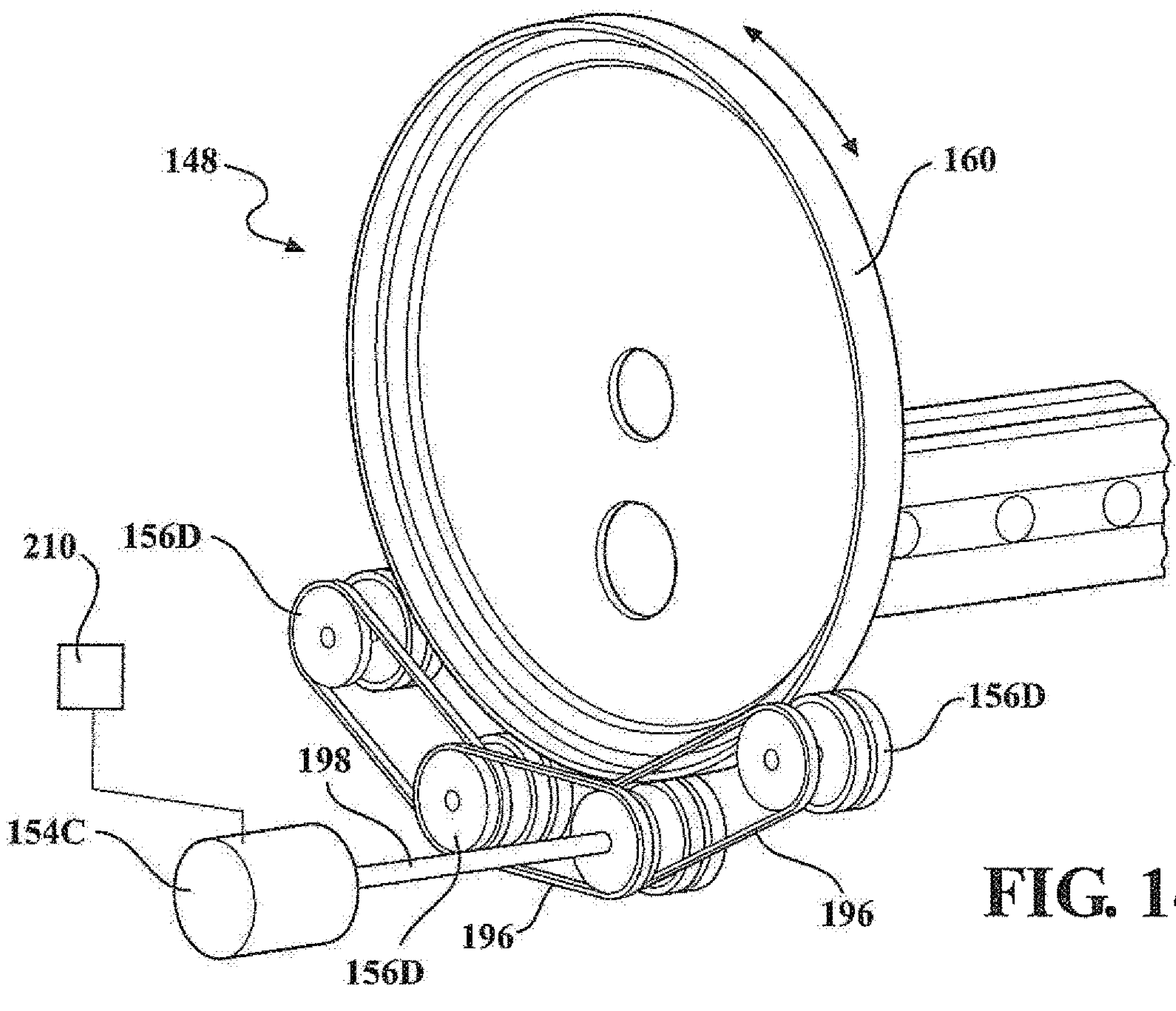
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FIG. 14

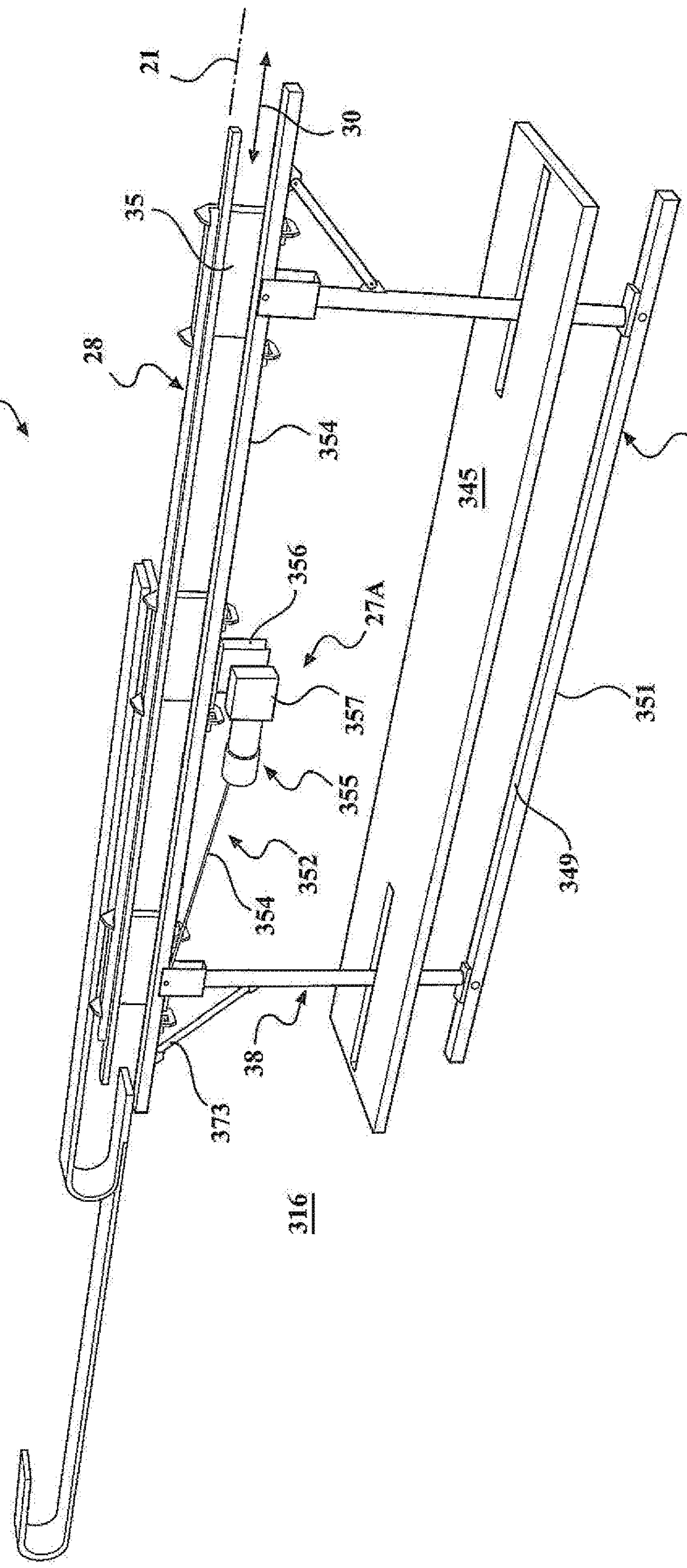
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FIG. 15

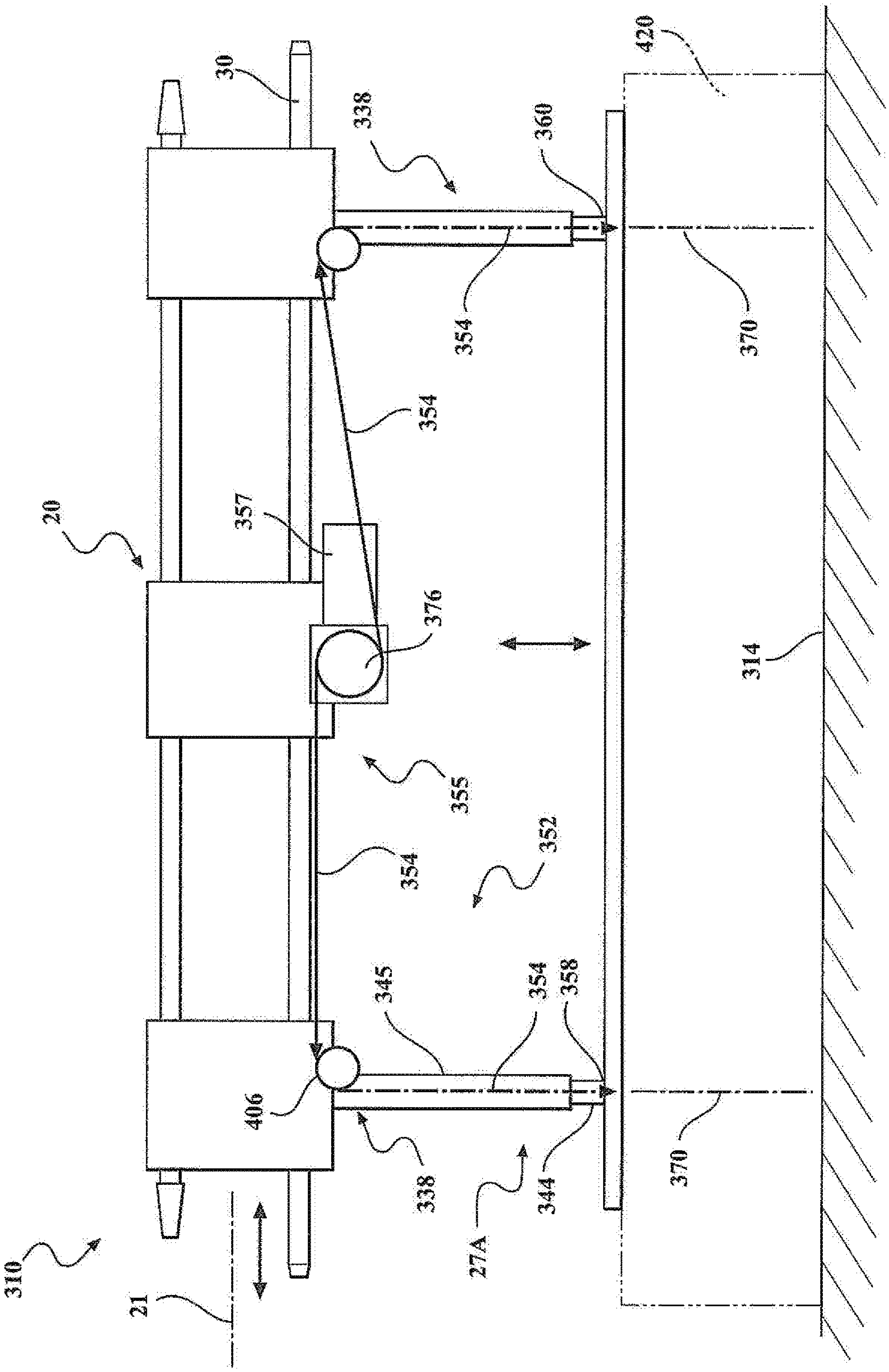

30
338
360
420
354
370
354
20
357
376
314
355
352
354
345
354
358
406
338
27A
344
370
310
21

FIG. 16

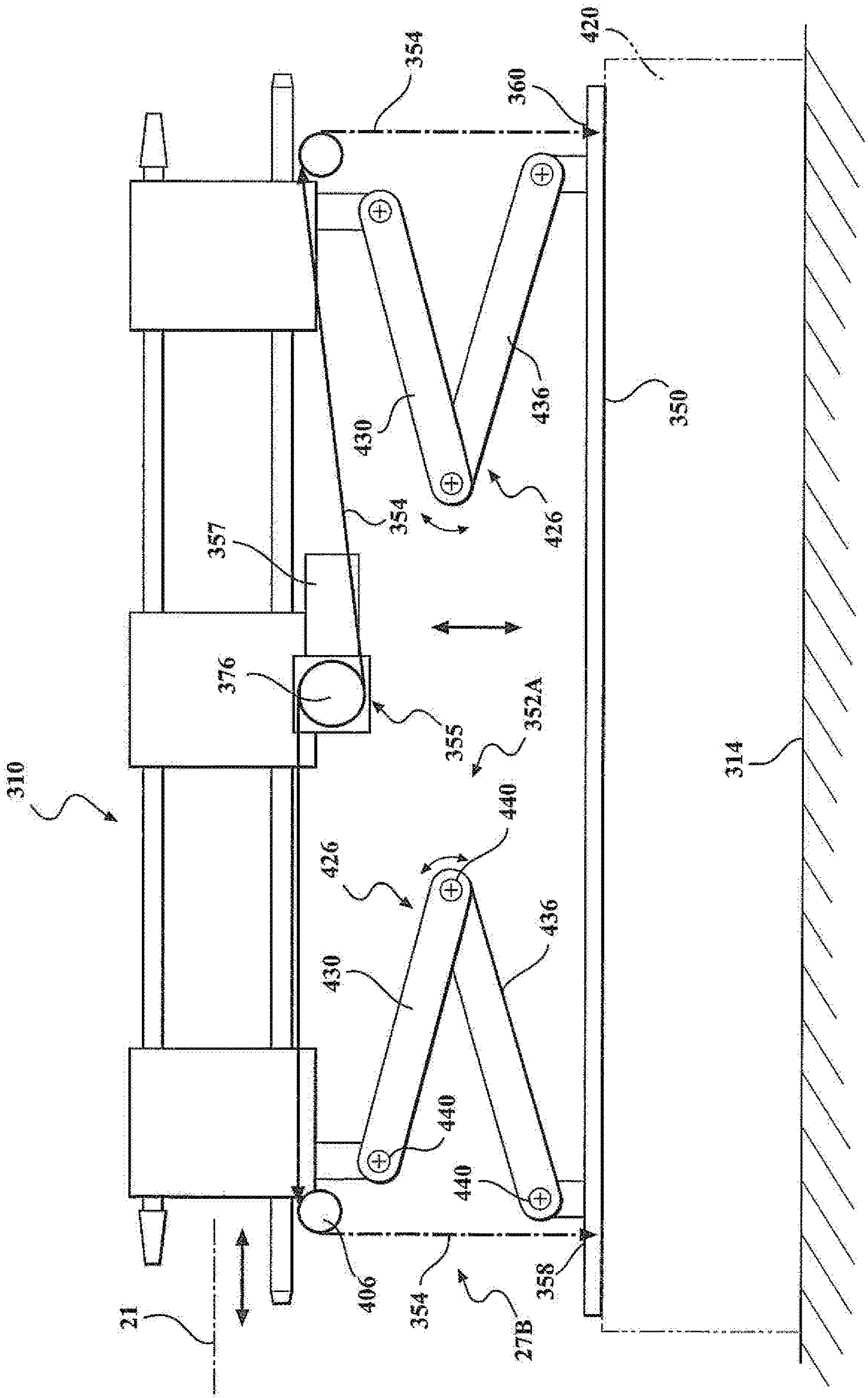

310
354
360
420
430
436
350
426
357
376
355
352A
314
440
406
358
27B
21

FIG. 17

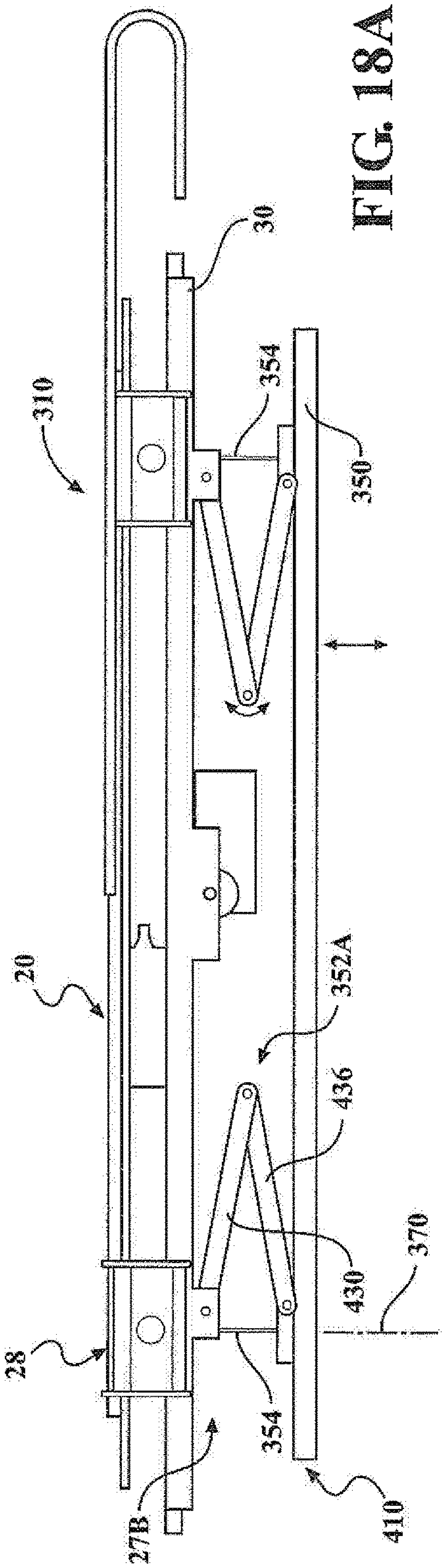


FIG. 18A

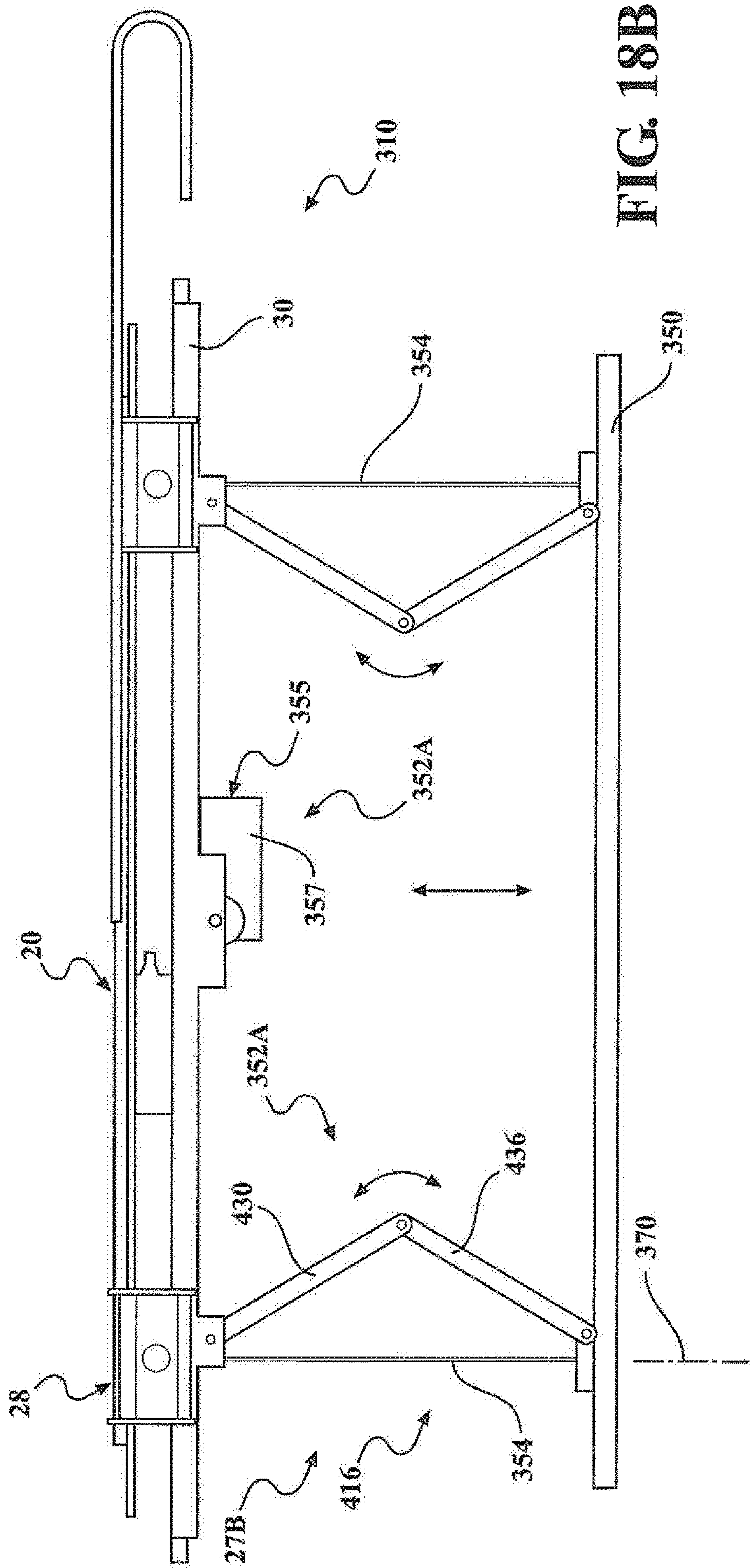


FIG. 18B

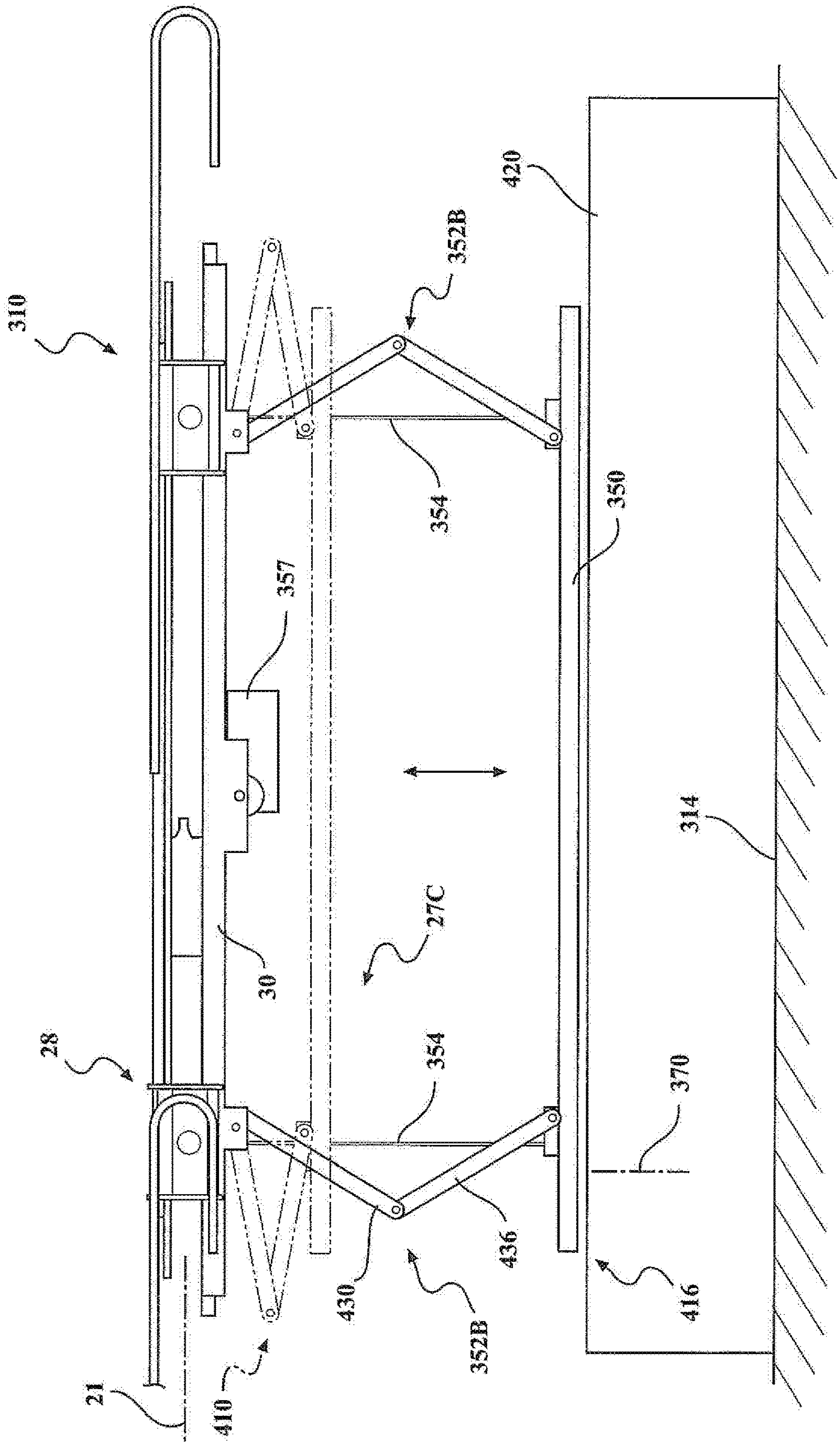

310
28
21
410
352B
352B
430
436
354
354
357
30
27C
350
420
314
370
416

FIG. 19

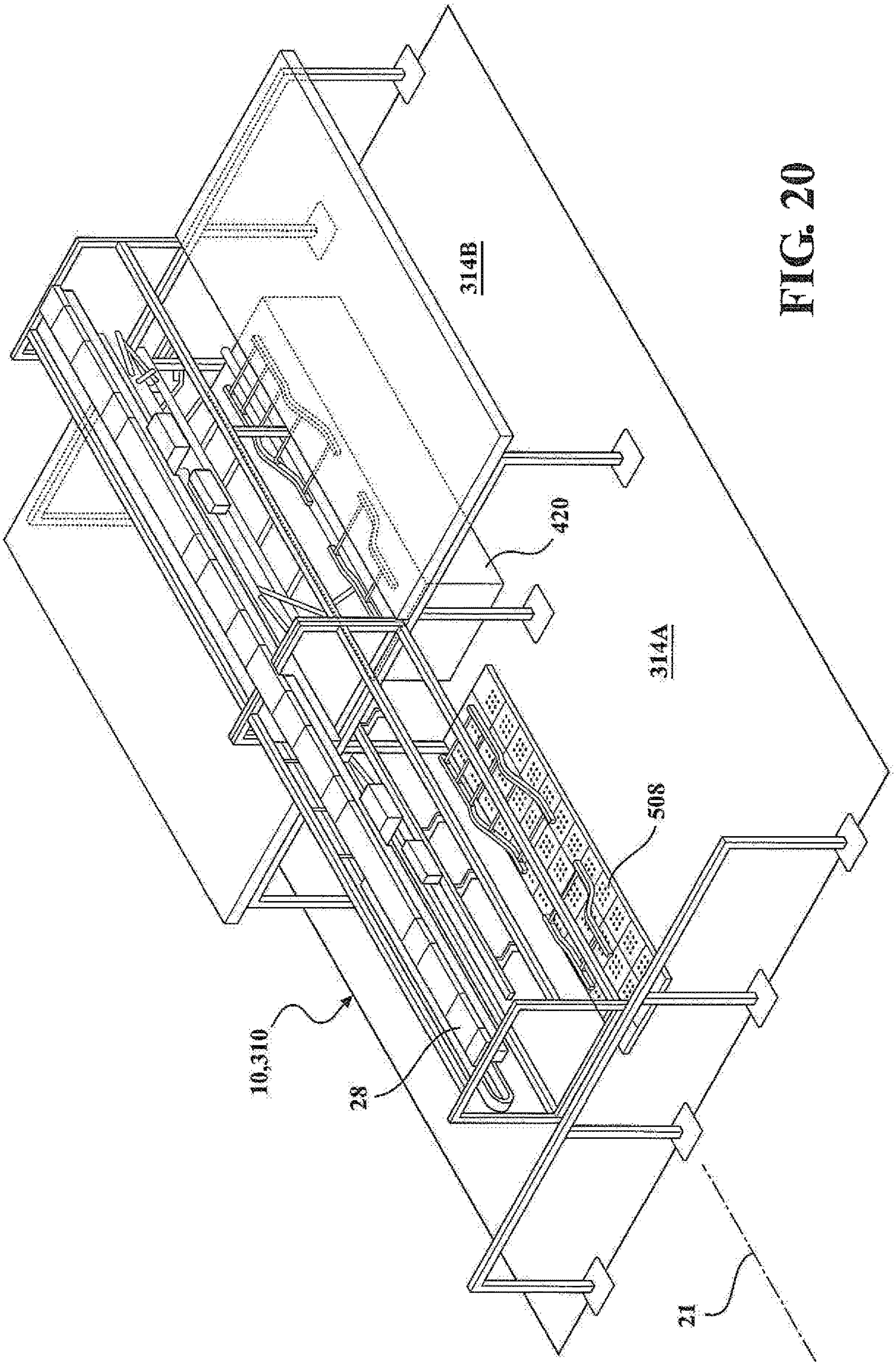
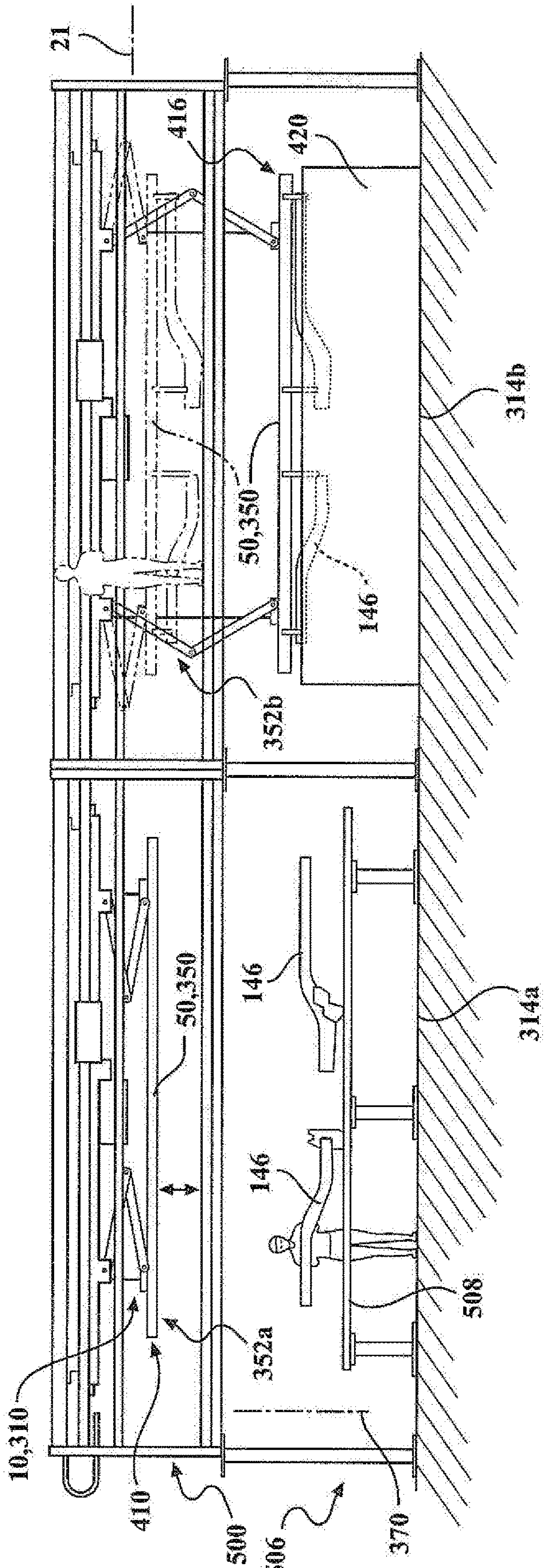


FIG. 20



21
416
420
50,350
146
352b
314b
146
50,350
146
314a
508
352a
10,310
410
500
506
370

FIG. 21

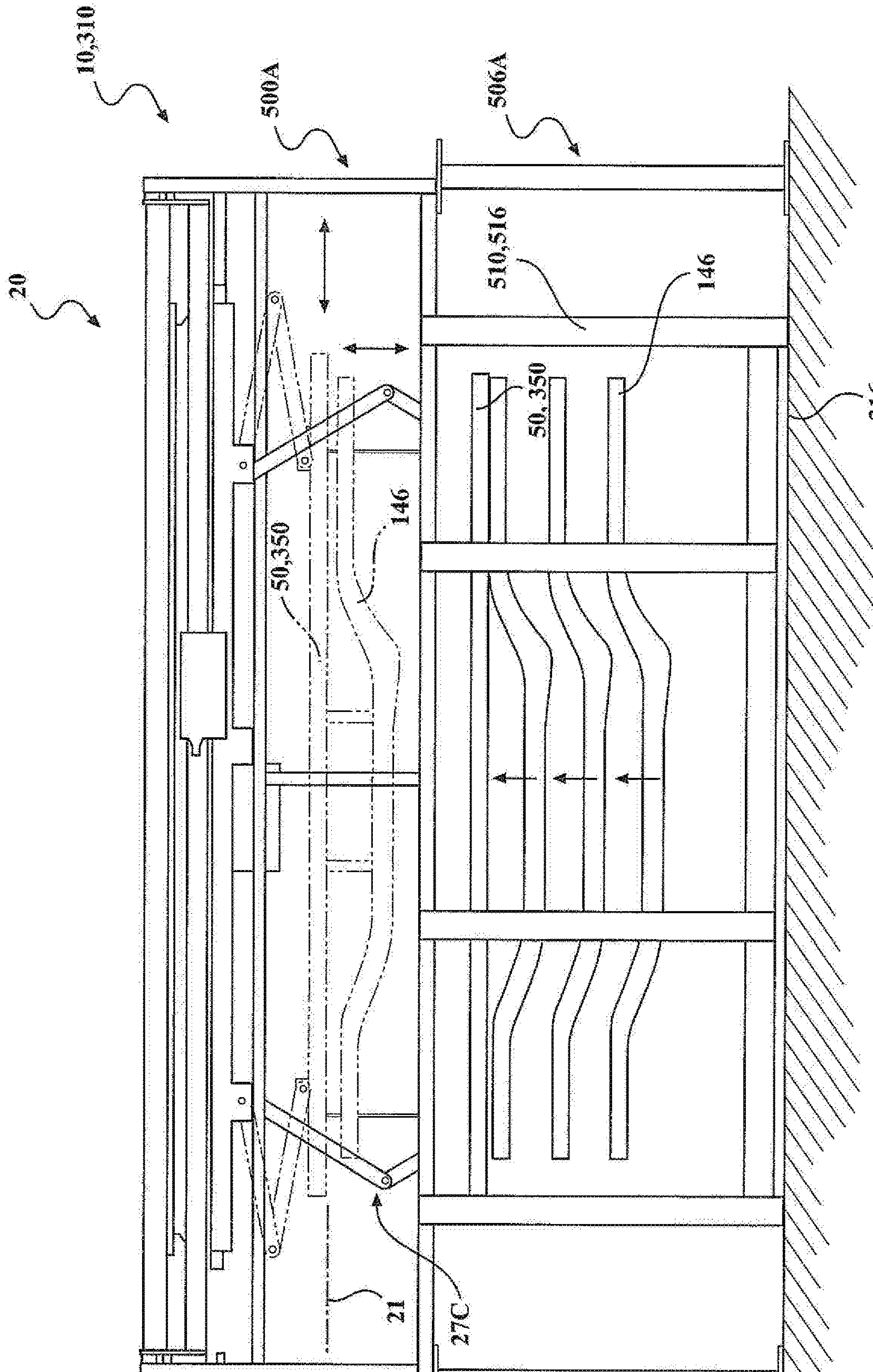


FIG. 22

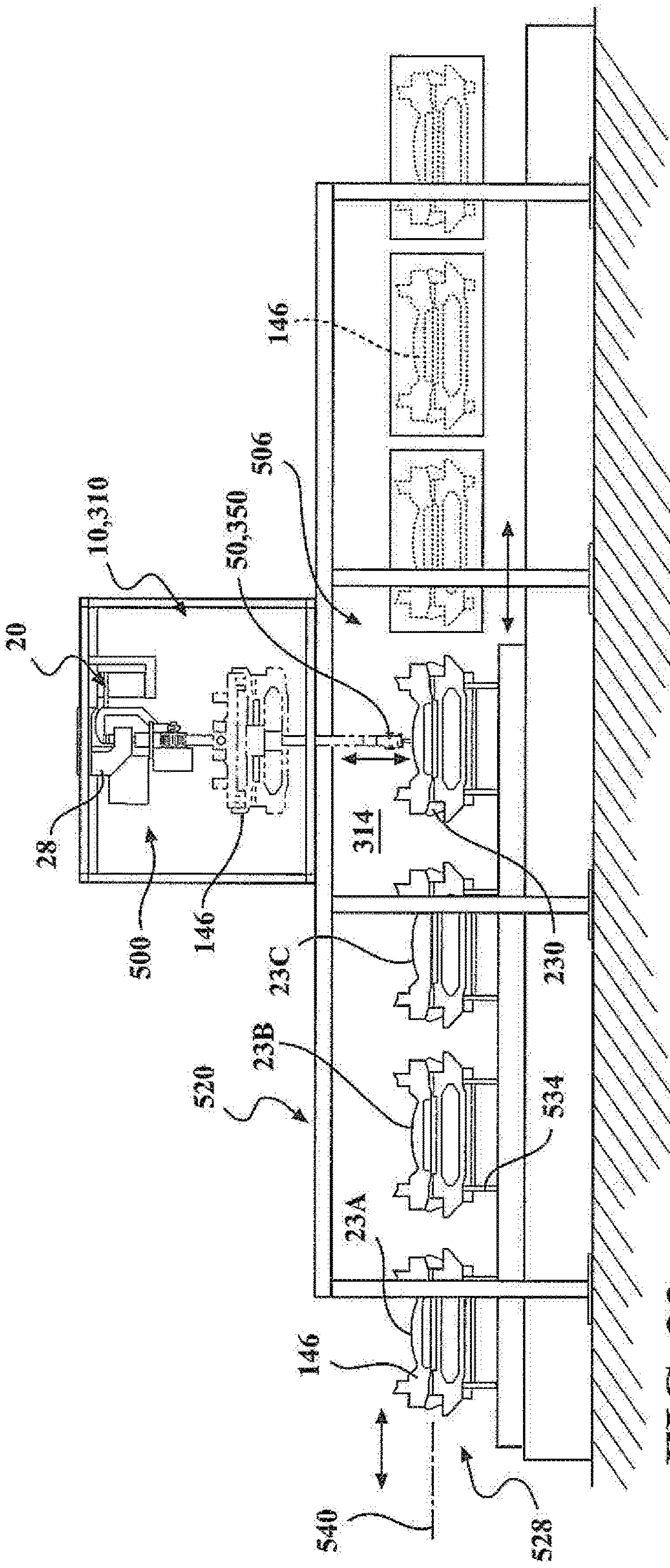

20
28
10,310
500
146
50,350
506
146
314
230
23C
23B
520
534
23A
146
540
528

FIG. 23

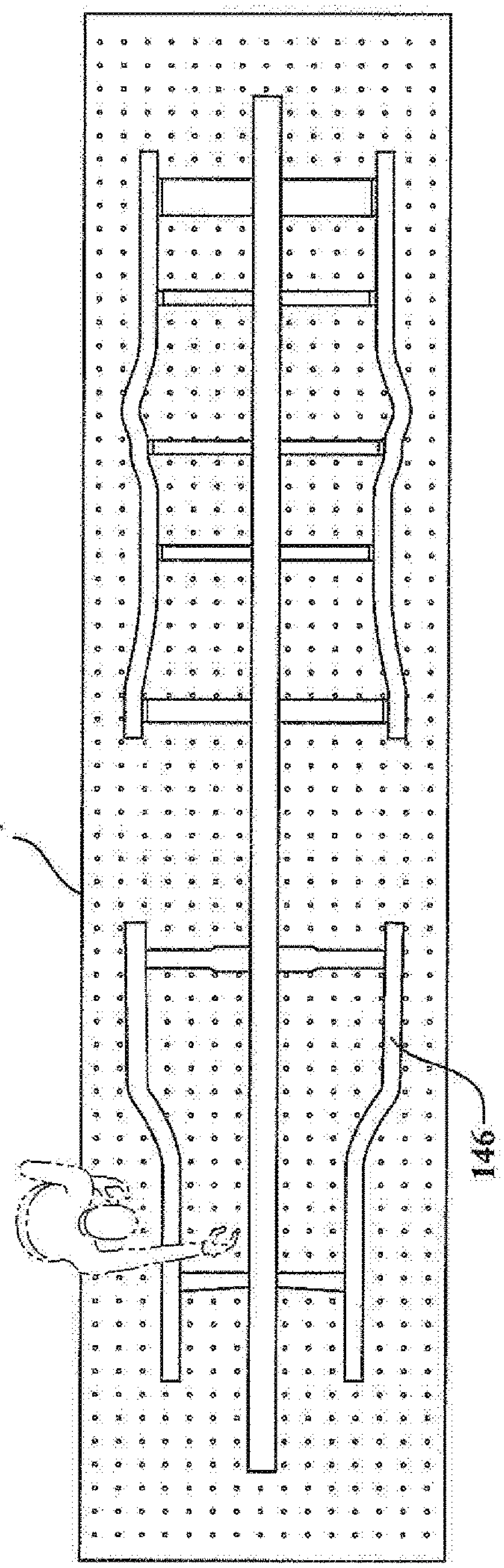

509,346
146

FIG. 24

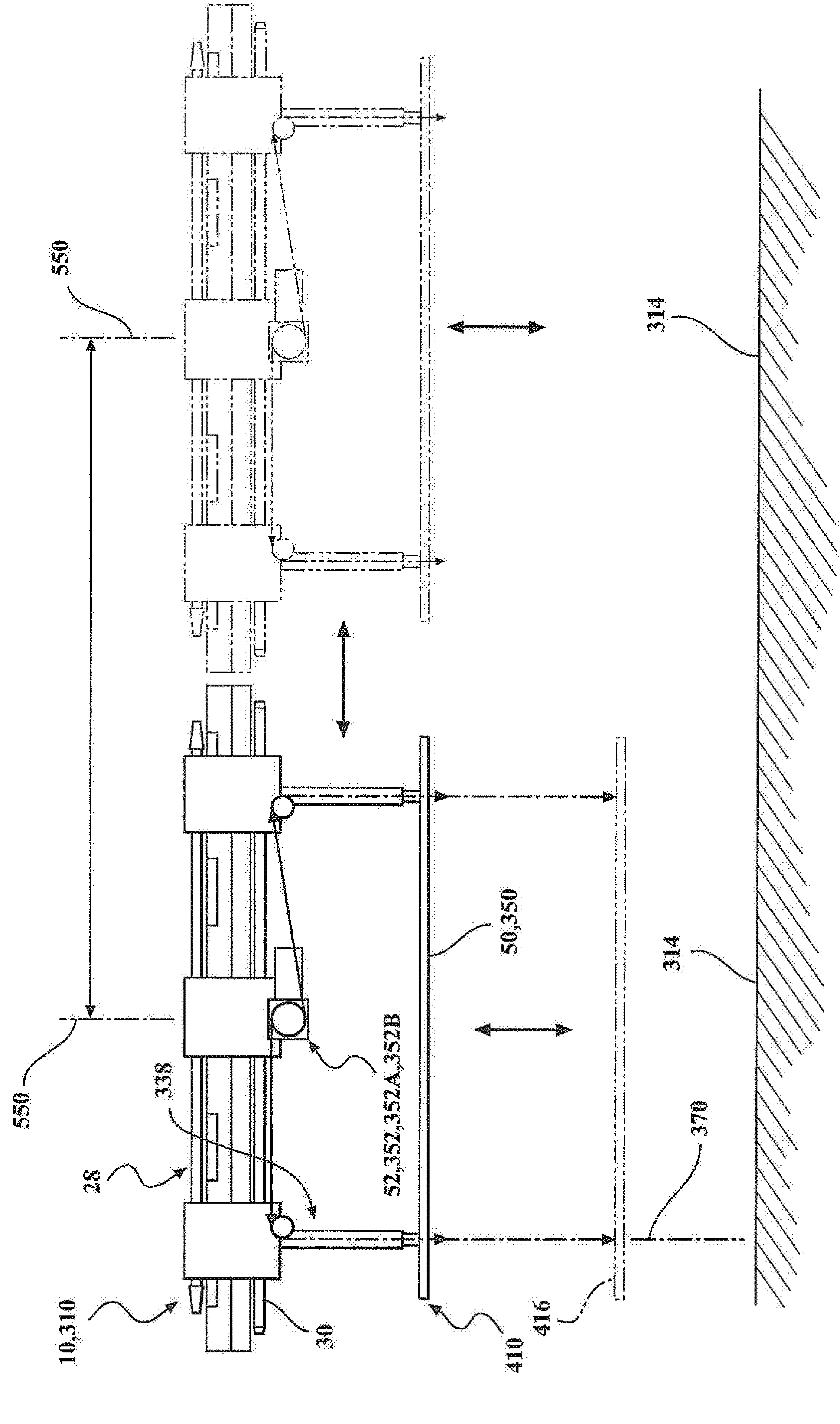

550
550
314
314
50,350
52,352,352A,352B
338
28
370
10,310
30
410
416

FIG. 25

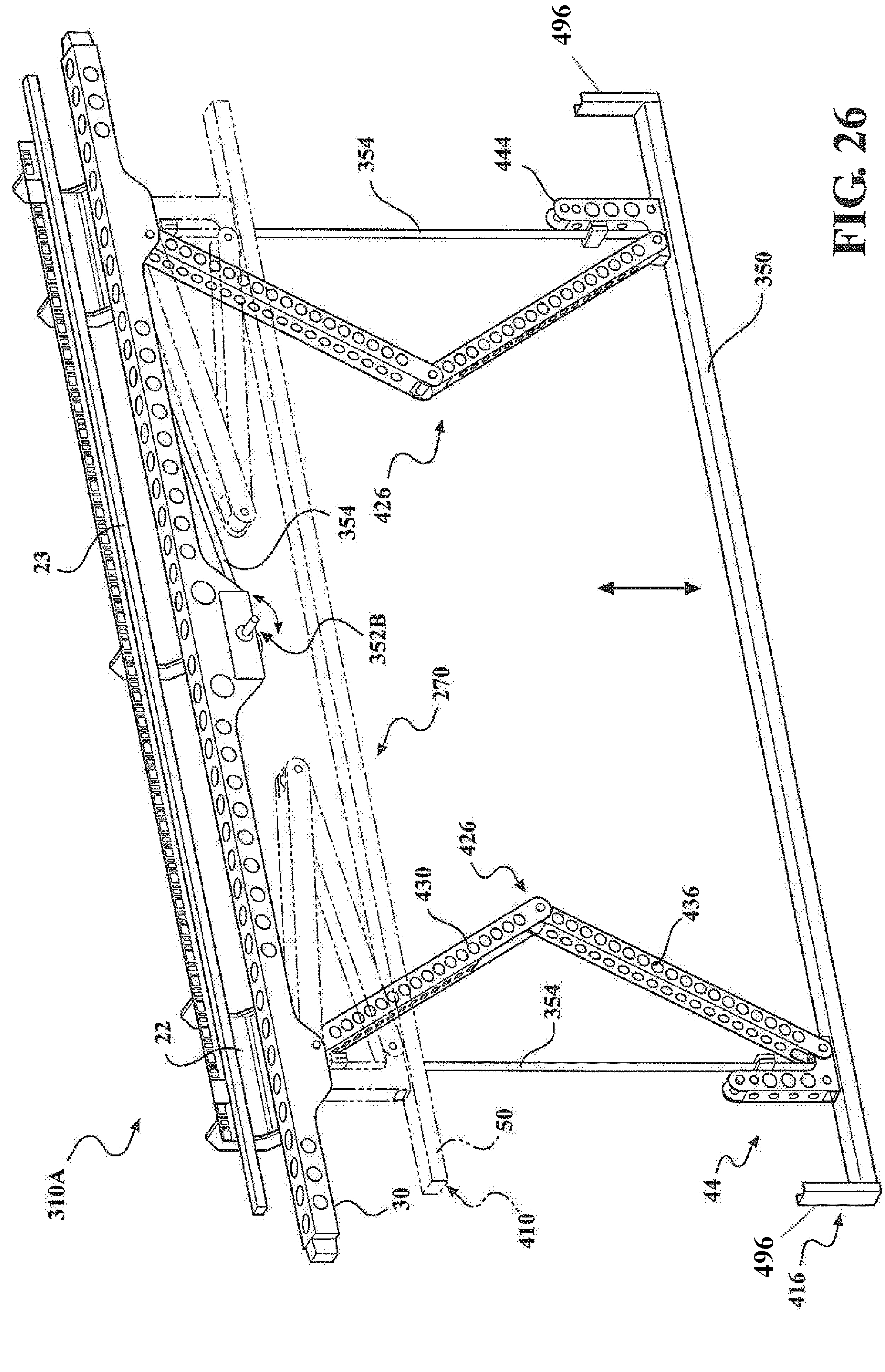

496
354
444
350
23
354
426
352B
270
426
430
436
354
22
310A
30
50
410
44
496
416

FIG. 26

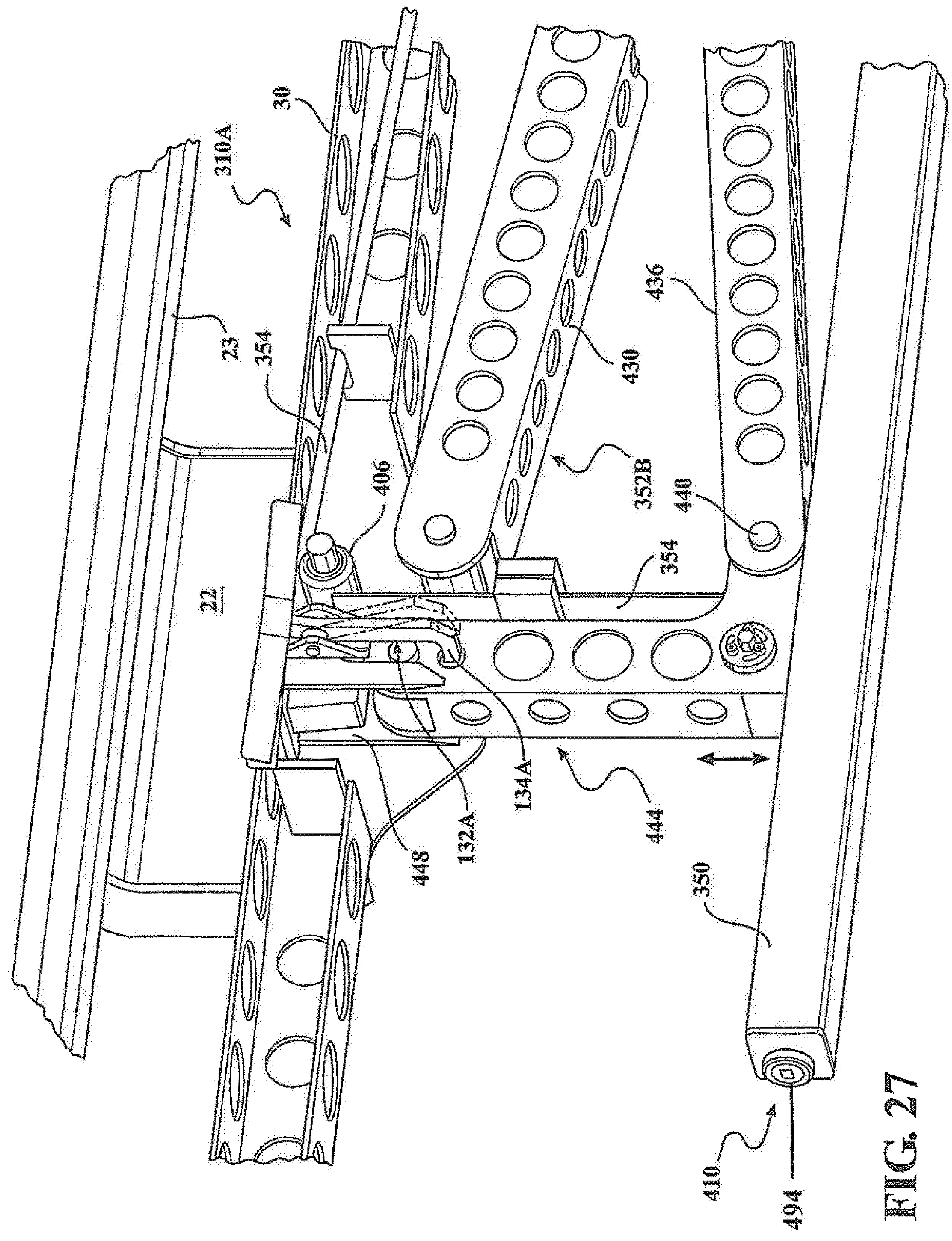

30
310A
23
354
22
406
430
436
352B
440
354
134A
132A
448
444
350
410
494

FIG. 27

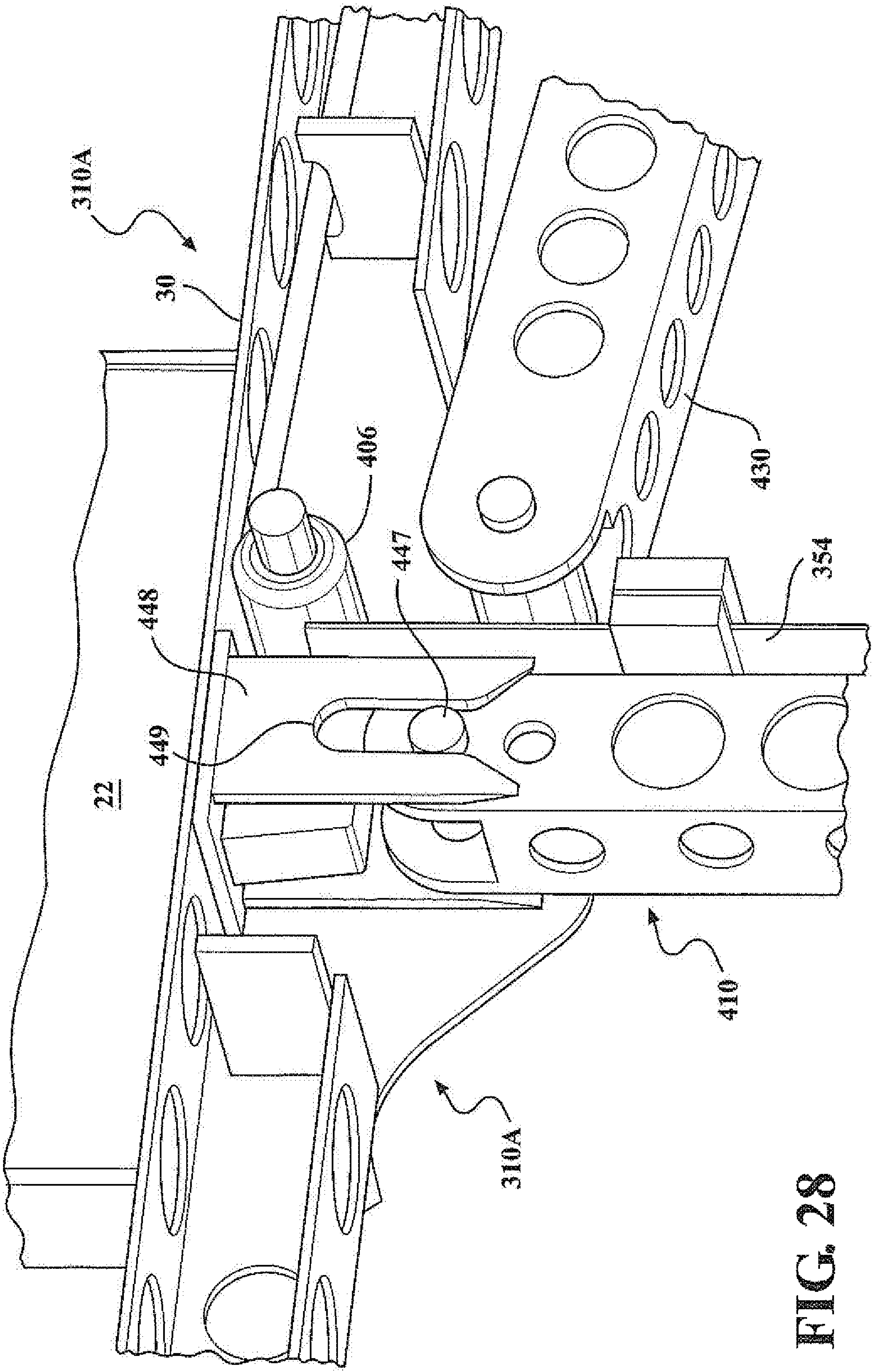


FIG. 28

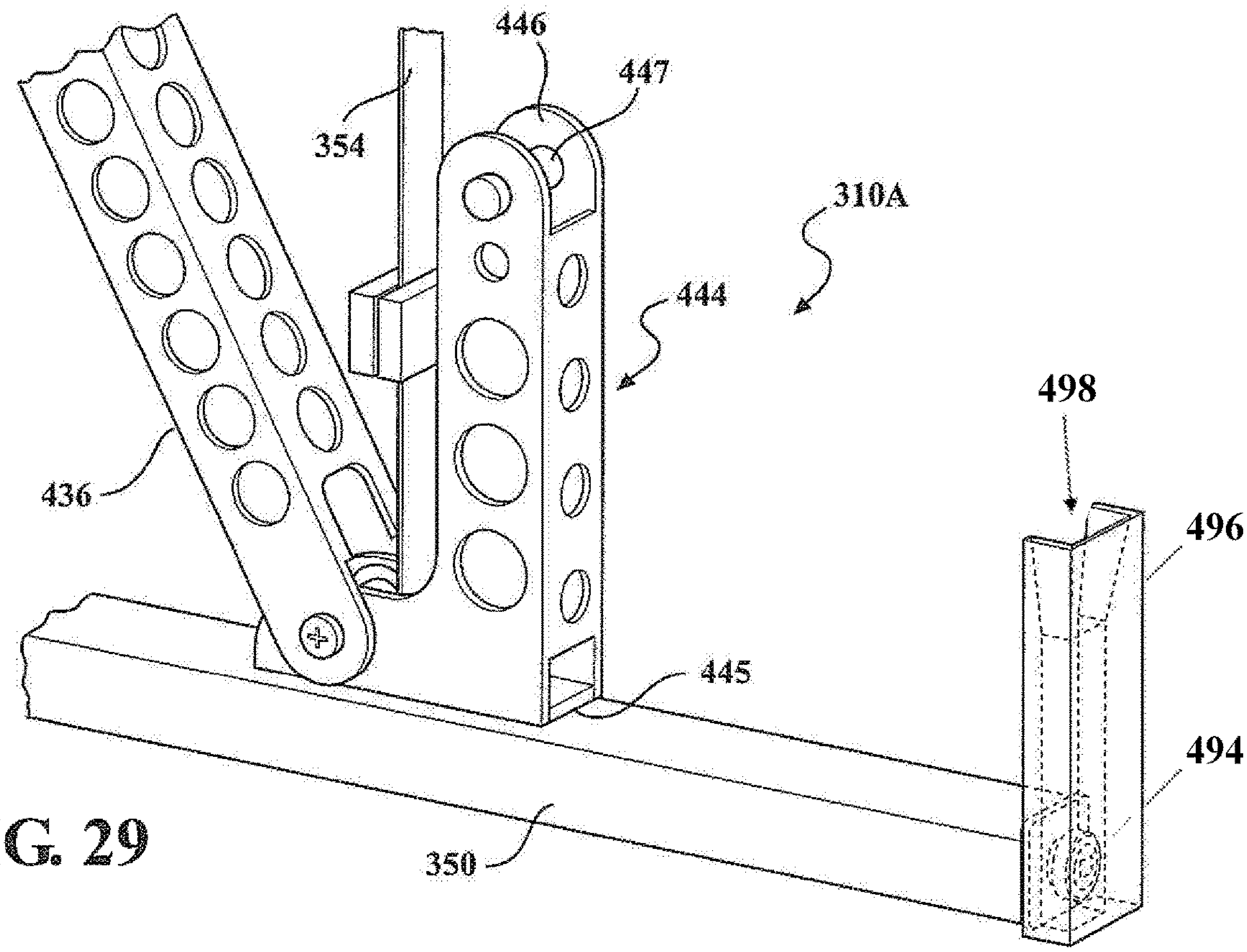

446
447
354
310A
444
498
496
436
445
494
350

FIG. 29

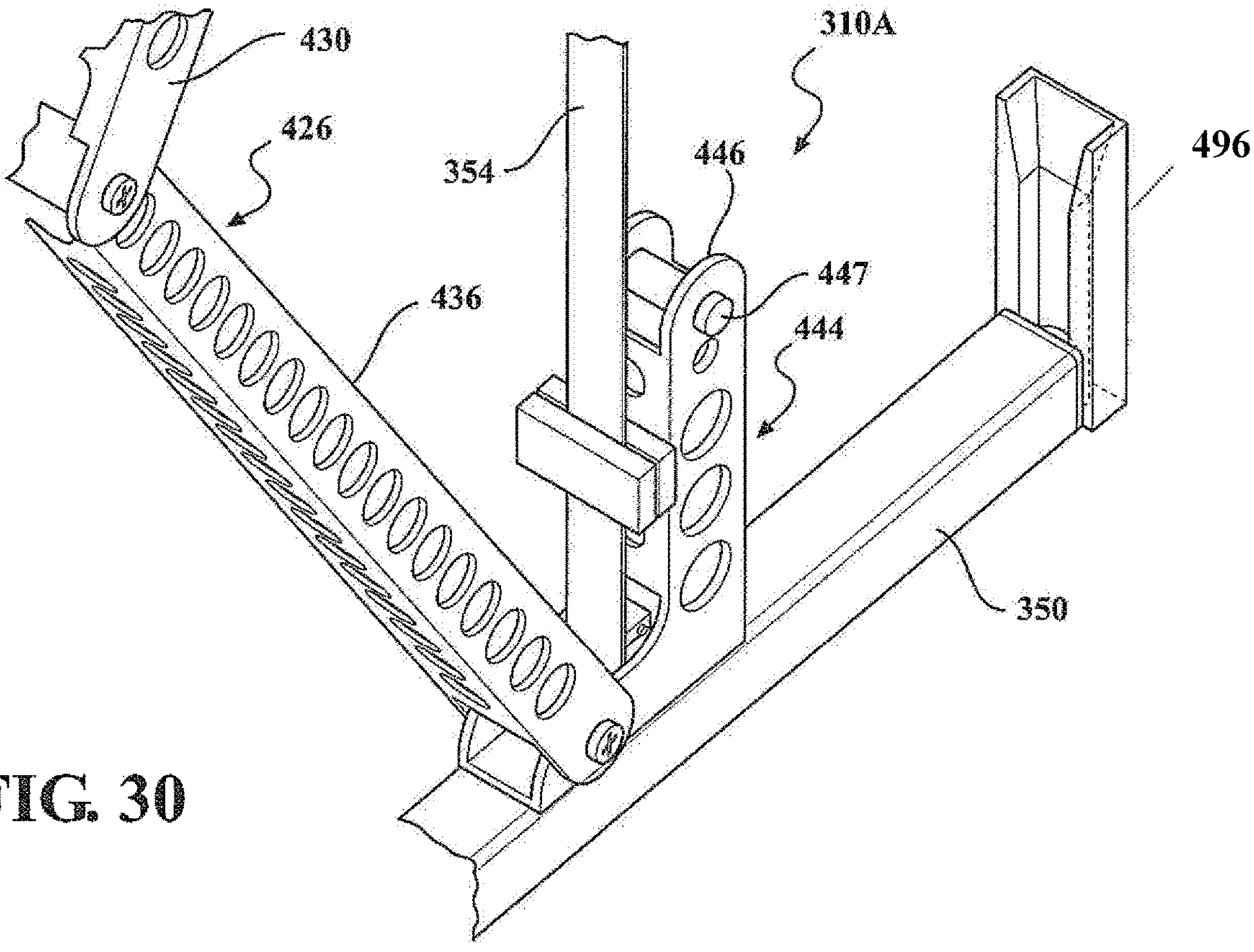

430
310A
426
354
446
496
447
436
444
350

FIG. 30

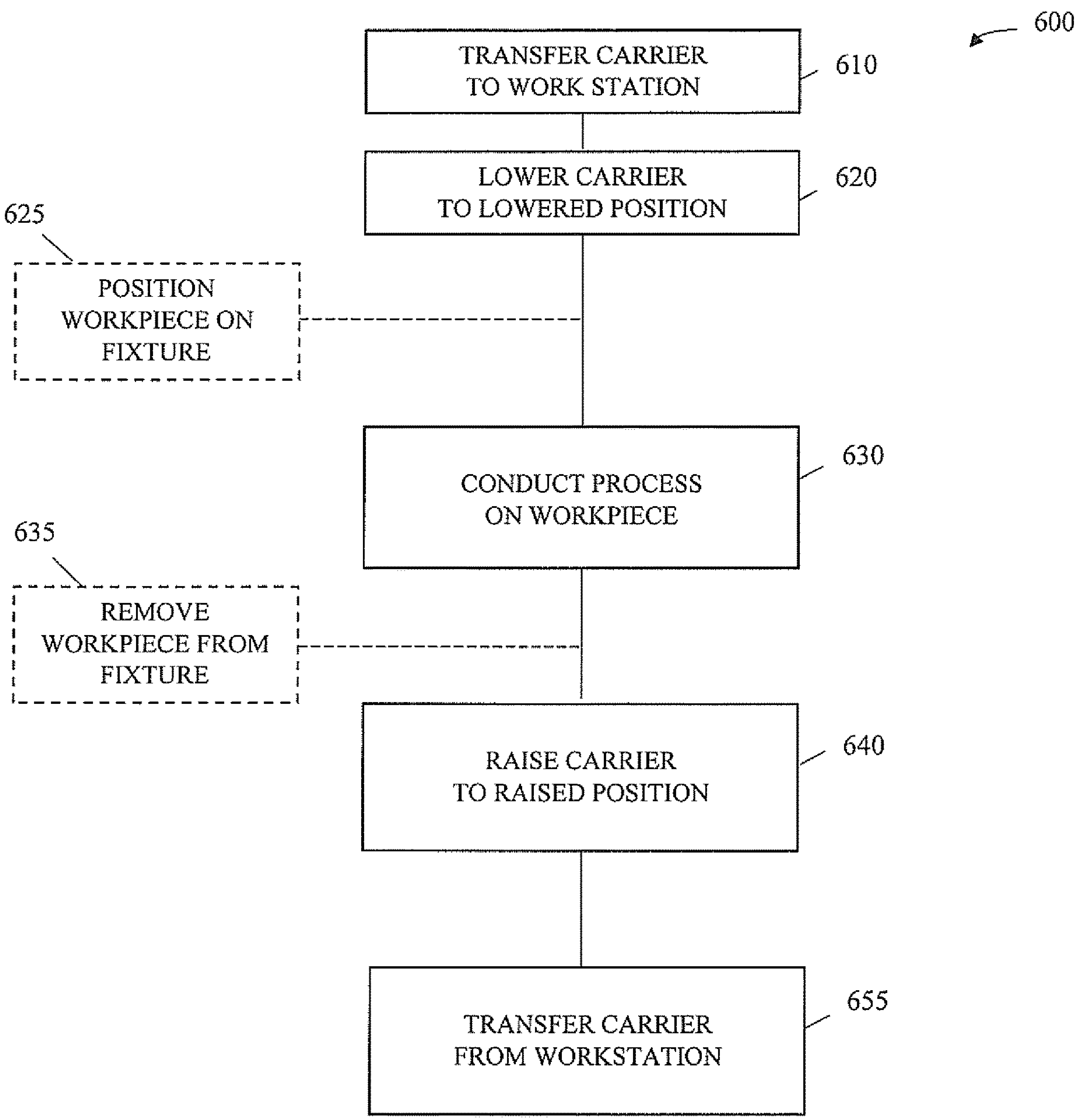

600
TRANSFER CARRIER TO WORK STATION
610
LOWER CARRIER TO LOWERED POSITION
620
625
POSITION WORKPIECE ON FIXTURE
CONDUCT PROCESS ON WORKPIECE
630
635
REMOVE WORKPIECE FROM FIXTURE
RAISE CARRIER TO RAISED POSITION
640
TRANSFER CARRIER FROM WORKSTATION
655

FIG. 31

INVERTED CARRIER LIFT DEVICE SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a divisional application of U.S. patent application Ser. No. 15/588,326 filed May 5, 2017 which claims priority benefit to U.S. Provisional Application No. 62/332,598, filed May 6, 2016, and U.S. Provisional Application 62/433,405, filed Dec. 13, 2016, the entire contents of each application are incorporated herein by reference.

TECHNICAL FIELD

The present invention pertains generally to assembly systems, particularly of the type including conveyors defining a path of travel between workstations for conveying of a workpiece to one or more workstations positioned along the path of travel.

BACKGROUND

In automotive production lines, individual workpieces, such as automotive body panels, frame components, etc., may be transported between workstations where selected operations, such as welding or other joining operations, are performed by workers, robots, or other processing equipment. Transporting individual workpieces to, and accurately placing the workpieces at, a desired workstation on a production line poses numerous difficulties. Tooling and other processing equipment at a workstation present obstacles that must be avoided by the incoming and departing workpieces. After reaching a given workstation, the workpieces must be accurately positioned within the workstation to allow necessary processing operations to be performed. Efficiency and accuracy requirements of modern production lines require that workpiece delivery to a workstation be as rapid and precise as possible.

In many common production lines and other assembly applications, workpieces are transported along an overhead rail, for instance a monorail. Powered roller rail systems move support trolleys or carriages between various workstations. Electrical conductors can be provided along the rail to provide power to the trolley motors. The trolleys carry workpieces along the path defined by the rail, delivering the workpieces to the workstations. To perform a processing operation on a workpiece transported along an overhead rail, often a mechanism must be provided to raise and lower the workpiece with respect to the workstation to properly position the workpiece in the workstation. Prior powered roller rail and trolley systems and devices used to raise and lower workpieces in a workstation include those described in U.S. Pat. Nos. 6,799,673; 9,513,625; and U.S. Patent Application Publication No. 2015/0128719 assigned to the assignee of the present invention and all incorporated herein by reference.

Many prior known mechanisms for raising and lowering a workpiece into the workstation have moved the entire workpiece-laden trolley along with an entire section of the overhead rail. This type of mechanism is complicated in design and prone to wear. For example, joints must be provided between the fixed and moveable rail sections to disengage and re-engage the rail and/or trolley to the main conveyor mechanism. It can be difficult to ensure that the section of rail lowered with the trolley is properly realigned

with the fixed rail sections. This negatively impacts the operational capacity of the production or assembly lines, for instance by causing wasteful "down-time" for repairs. In addition to the foregoing disadvantages, many prior known mechanisms cycle at relatively slow speeds, since the weight of the carrier, trolley, and rail must all be borne by the movement mechanism. Consequently, a need exists for a simplified lifting mechanism that meets the efficiency requirements of modern production and assembly lines, and which is simple in operation.

SUMMARY

The inventive inverted carrier lift device system and method is useful to transport a workpiece along an assembly line and to selectively lower and raise the workpiece in a predetermined area for processing or temporary storage of the workpiece. The carrier lift may selectively and automatically release the workpiece into a fixture or other device for processing and thereafter automatically re-engage the workpiece for continued movement along the assembly line.

In one example, the carrier includes an onboard lifting mechanism having a ratcheting device and a tether for raising and lowering a support beam engaged with the workpiece through workpiece engaging devices. The lifting mechanism is selectively engageable with a motor stationarily positioned at a workstation which rotates the ratchet device to raise and lower the workpiece. In a lowered position, the workpiece engaging devices are automatically actuated to release the workpiece from the support beam into a desired holding fixture or other device for further processing or storage. Following further processing or storage of the workpiece in the workstation, the carrier is positioned, lowered and automatically re-engaged with the workpiece. The carrier is then raised by the lifting mechanism and selectively moved along the assembly line to another predetermined position.

In one example, the ratchet device includes a drum which threadingly engages a single tether connected at both ends to the workpiece support beam, on rotation of the ratchet device by the motor, the tether is spooled onto, or unspooled from, the drum to raise or lower the workpiece respectively.

In another example, the carrier is connected to a trolley engaged with and elevated or overhead conveyor for movement of the carrier along an assembly line through a plurality of workstations.

In another example, the carrier is used with a trunnion fixture positioned in a workstation along the assembly line. At a lowered position, the carrier positions and releases the workpiece to the trunnion fixture which rotatably manipulates the workpiece to one or more predetermined positions for processing of the workpiece.

The inventive method for raising and lowering a workpiece in a workstation is useful for selectively vertically positioning a workpiece in a workstation for processing or temporary storage of the workpiece in the workstation or other location. In one example, a carrier is connected to a trolley engaged with an elevated or overhead carrier movable along an assembly line. The carrier selectively raises or lowers the supported workpiece relative to the trolley to position the workpiece on a fixture or other device positioned in the workstation.

In one example of the method, the carrier automatically releases the workpiece into the fixture or other device and then re-engages the workpiece following processing or storage for further movement along the assembly line.

In another example an alternate lift mechanism including an extension device using scissor links is used to raise and lower the workpiece.

In another example, the actuating motor for selectively raising and lowering the workpiece is onboard the lift carrier instead of stationarily positioned at the workstation independent of the carrier.

These and other aspects of the present disclosure are disclosed in the following detailed description of the embodiments, the appended claims and the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

FIG. **1** is a front perspective view of an inverted carrier lift system used with an overhead conveyor system;

FIG. **2** is a rear perspective view of the overhead conveyor system in FIG. **1**;

FIG. **3** is a front view of the overhead conveyor system in FIG. **1** with a carrier arranged in a lowered position;

FIG. **4** is a front perspective view of the overhead conveyor system in FIG. **1** with the carrier arranged in a raised position;

FIG. **5** is a partial cross-sectional view of the overhead conveyor system taken along section line **5**-**5** of FIG. **3**;

FIG. **6** is an enlarged perspective view of an exemplary ratchet mechanism used in the system shown in FIG. **1**;

FIG. **7** is a partial cross-sectional view of the ratchet mechanism taken along section line **7**-**7** of FIG. **6** showing engagement with a tether;

FIG. **8** is a front view of an example of a ratchet coupler that may be employed with the ratchet mechanism of FIG. **6**;

FIG. **9** is a side view of the ratchet coupler of FIG. **8**;

FIG. **10** is a side view of an exemplary drive motor that may be used to actuate the ratchet mechanism of FIG. **6**;

FIG. **11** is a partial side view of an exemplary auxiliary latch mechanism that may be employed with the system of FIG. **1**;

FIG. **12** is a partial front perspective view of an exemplary rotary drive configured for rotatably driving multiple rollers used to support an exemplary trunnion fixture;

FIG. **13** is a partial front perspective view of an alternately configured exemplary rotary drive configured for rotatably driving multiple rollers used to support the trunnion fixture in FIG. **12**;

FIG. **14** is a partial front perspective view of yet another alternately configured rotary drive system configured for rotatably driving multiple rollers used to support the trunnion fixture in FIG. **12**; and

FIG. **15** is a perspective view of one example of a flexible elevated transport carrier;

FIG. **16** is a side view of an example of the flexible elevated transport carrier;

FIG. **17** is a side view of an alternate example of a flexible elevated transport carrier;

FIG. **18**A is an alternate side view of the example the flexible elevated transport carrier of FIG. **3** shown in a raised position;

FIG. **18**B is an alternate side view of the example of a flexible elevated transport carrier of FIG. **3** shown in a lowered position;

FIG. **19** is a side view of an alternate example of a flexible elevated transport carrier shown concurrently in a lowered and a raised position;

FIG. **20** is a perspective view of an example application of one example of a flexible elevated transport carrier;

FIG. **21** is a side view of the example shown in FIG. **20**;

FIG. **22** is a side view of an example application of one example of a flexible elevated transport carrier;

FIG. **23** is an end view of an example application of one example of a flexible elevated transport carrier in use with a component buffer shuttle;

FIG. **24** is a top view of one example of a flexible elevated transport carrier showing example components;

FIG. **25** is a side view of one example of a flexible elevated transport carrier;

FIG. **26** is a perspective view of an alternate example of the transport carrier showing the carrier in both a raised and a lowered position;

FIG. **27** is an enlarged perspective view of a portion of the transport carrier of FIG. **26** in a raised position;

FIG. **28** is an enlarged partial perspective view of a portion of the transport carrier of FIG. **26**;

FIG. **29** is an enlarged partial perspective view of a portion of the transport carrier of FIG. **26**; and

FIG. **30** is an enlarged alternate perspective view of a portion of the transport carrier of FIG. **26**; and

FIG. **31** is a flow chart of an example of a method for selectively raising and lowering a workpiece in a workstation

DETAILED DESCRIPTION

Referring to FIGS. **1**-**4**, an example of an inverted carrier lift **10** used with an elevated or overhead conveyor system **20** is shown. The overhead conveyor **20** may include an elevated or overhead support frame (not shown) of any configuration suitable for supporting loads to be transported along a path of travel **21**. The support frame structure may include a programmable powered roller mechanism which is operable to selectively move the inverted carrier lift **10** along the path of travel **21** through a plurality of workstations. Suitable frames or support structures are disclosed in U.S. Pat. Nos. 6,799,673; 8,201,723 and/or 9,513,625.

As best seen in FIG. **2**, the support frame includes brackets **22** that support an elongated guide rail **24** which serves to support the inverted carrier lift **10** and defines the path of travel **21** for the overhead conveyor **10**. A plurality of powered rollers **26** (see FIG. **2**) may be rotatably mounted to the guide rail **24** in fixed locations spaced along the path of travel **21**. One or more motors (not shown) may be employed to rotatably drive at least a portion of the rollers **26**. At least some of the rollers **26** may be operably associated with one another to rotate substantially in unison. A suitable powered roller overhead transport system is described in U.S. Pat. No. 6,799,673.

The powered rollers **26** may be controlled by a programmable control system used to monitor, sequence and control the movement of the individual inverted carrier lift trolleys discussed below along an assembly line. One example of a suitable control system is described in U.S. Patent Application Publication No. US 2010/0241260 assigned to the assignee of the present invention and incorporated by reference herein.

The inverted carrier lift **10** may be selectively and precisely positioned at one or more locations in a workstation through a closed loop control system including an optical reader positioned at the station and coded strips or other devices on the carrier **27**. The coded strips may be specific to the particular carrier lift **27** or the workpiece transferred by the carrier **27** such that on a carrier **27** entering a workstation, the optical reader scans the coded strip identifying information on the strip, which may be particular to the specific carrier **27**, and the carrier **27** can be stopped at a predetermined or optimal position in the workstation for the work to be performed on the workpiece. One suitable transport monitoring, control and positioning system is disclosed in U.S. Pat. No. 7,108,189 owned by the assignee of the present invention and is incorporated herein by reference. An example of the coded strip is shown atop rail **23** in FIG. **26**. Other frame supports, overhead carrier transport devices, and monitoring, control and positioning systems known by those skilled in the art, may be used. While the exemplary overhead conveyor system **20** is configured as a single monorail overhead system, other configurations of overhead conveyor systems may be employed, including but not limited to multi-rail systems.

As best seen in FIG. **2**, the exemplary inverted carrier lift system **10** includes a carrier **27** connected to a trolley **28** supported by the overhead conveyor system **20**. In the example, trolley **28** includes an elongate support member **30** including a first end **32** and a second end **34**. Two or more c-shaped arms **35** (three shown) rigidly connect the support member **30** to the support rail **23** which, by weight of gravity, frictionally engages the rollers **26** for movement along the guide rail **24** in response to rotation of the powered rollers **26**. The trolley **28** is moveable along the guide rail **24** and is selectively controllable to selectively stop at one or more workstations or assembly cells located along the path of the conveyor system **20** as previously described above. The c-shaped arms **35** may be of other constructions, figurations and orientations. Other devices and methods for supporting trolley **28** on a powered overhead conveyor system, and moving the trolley **28** from workstation to workstation, known by those skilled in the art may be used.

The exemplary inverted carrier **27** includes a workpiece support beam **36** suspended from the trolley **28** by two telescopic posts **38**. The workpiece support beam **36** is selectively movable between a raised position, for example, as shown in FIG. **4**, and a lowered position, for example, as shown in FIGS. **1-3** along a carrier path of travel. An upper end **40** of each telescoping post **38** is attached to the trolley **28** support member **30** and a lower end **42** is attached to the carrier **36**. The telescopic posts **38** are operable guide the raising and lowering of the workpiece support beam **36** and to restrict lateral movement of the workpiece support beam **36** when moving between the raised and lowered positions.

In the example, each telescopic post **38** includes a lower post member **44** slidably received within an upper post member **46**. In the illustrated exemplary configuration, the upper post member **46** is shown attached to the trolley **28** and the lower post member **44** attached to the workpiece support beam **36**, but in practice, the orientation of the telescoping post **38** may be inverted, such that the lower post member **44** is attached to the trolley **28** and the upper post member **46** is attached to the carrier **36**. As illustrated, when operating the carrier **27**, the lower post member **44** moves progressively further into the upper post member **46** when moving the workpiece support beam **36** toward the raised position, and extends progressively further out from the upper post member **46** when moving the workpiece support beam **36** toward the lowered position. The telescopic post **38** may include an alternate configuration to accommodate the design and performance requirements of a particular application. More than two telescopic posts **36** may be employed with the carrier **27**.

Referring to the example carrier **27** shown in FIGS. **1** and **2**, workpiece support beam **36** is shown as a generally horizontal support member extending between, and attached to, the two telescopic posts **38**. Workpiece support beam **36** may further include one or more auxiliary arm supports **50** attached to and extending generally outward from the horizontal member **48**. The workpiece support beam **36** may also support interchangeable antlers (vertical oriented fixtures or tooling posts, not shown) for carrying various configurations of workpieces (including subassemblies) between workstations for processing. Examples of the referenced antlers are disclosed in U.S. Pat. No. 6,557,690 the entire contents of which is incorporated by reference. The carrier **27** including workpiece beam support **36** may be moved from the raised transport position, for example raised up close to support member **30**, to a lowered transfer position, for example as shown in FIGS. **1** and **2**, when stopped at a predetermined position at the workstation as further described below. Alternate constructions, configurations and orientations of horizontal member **48**, auxiliary arms **50** and telescopic posts **38** may be used to suit the workpiece being supported or the general assembly/process line application.

With reference to the example shown in FIGS. **1-4**, the carrier lift system **10** includes a lifting mechanism **52** operable for selectively moving the carrier **27** including workpiece support beam **36** between the raised position and lowered position. The exemplary lifting mechanism **52** includes a flexible tether **54** attached to the workpiece support beam **36** and engaged with a ratchet mechanism **56**. The ratchet mechanism **56** may be rotatably driven by a motor **57** (see FIG. **10**) stationarily mounted at a workstation and further described below to cyclically retract and extend the tether **54** to raise and lower the workpiece support beam **36**. The tether **54** may include various configurations and materials, for example, braided steel cable, woven nylon straps, reinforced belts, chains and other devices known by those skilled in the art

In one example of the illustrated tether **54**, tether **54** includes a single, continuous member that is threaded through the ratchet mechanism **56** further discussed below, and attached at both a first end **58** and a second end **60** to the carrier **36** at a first attachment point **59** and a second attachment point **61**, respectively. A buckle **62** may be used to attach the ends **58** and **60** of the tether **54** to the carrier **36**.

In the example shown, tether **54** passes through a pair of pulleys **64** attached to the support member **30** spaced on either side of the ratchet mechanism **56** as generally shown. As best seen in FIG. **3**, the pulley **64** includes a pulley roller **66** rotatably mounted to a bracket **68** that may be attached to the guide rail **24**. A shaft **70** may be used to rotatably connect the pulley roller **66** to the bracket **68**.

The pair of pulleys **64** may be spaced apart along the guide rail **24** by a distance that approximates the spacing between the attachment points **59** and **61** of the tether **54** to workpiece support beam **36**. To maximize lifting efficiency of the lifting mechanism **52**, the pulleys **64** may be spaced such that portions of the tether **54** located between the pulleys **64** and the tether connection points **59** and **61** are arranged substantially parallel to one another. A different pulley **64** spacing may be employed, but may result in reduced lifting efficiency.

Referring to FIGS. **6** and **7**, the exemplary ratchet mechanism **56** is connected to the trolley **28** support member **30**. The exemplary ratchet mechanism includes a rotatable drum

72 fixedly attached to a ratchet shaft **74**. The ratchet shaft **74** is rotatably mounted to a ratchet housing **76** that attaches to the support member **30**. To allow for generally free rotation of the drum **72** relative to the ratchet housing **76**, the ratchet shaft **74** may be supported on one or more bearings (not shown) mounted within a bearing cup **78** attached to the ratchet housing **76**.

In the example shown, the drum **72** includes a first drum end plate **80** and a second drum end plate **82**. A plurality of elongate rods **84** extend between the first **80** and second **82** drum end plate, each rod with a first end **86** attached to the first drum end plate **80** and an opposite second end **88** attached to the second drum end plate **82**. In one example, the rods **84** may be arranged generally perpendicular to the first **80** and second **82** drum end plates. The rods **84** may also be arranged in a circle so as to form linear segments generally defining an outer perimeter of a cylindrical-shaped structure extending between the first **80** and second **82** drum end plates. In the example best seen in FIG. **7**, each rod **84** is equally radially spaced from, and equally angularly spaced, relative to ratchet shaft **74** as generally shown. Alternate constructions of drum **72** and rods **84** may be used. For example, more or less rods **84** may be used as well as the radial and angular position and spacing of the rods **84** relative to each other and ratchet shaft **74**. Alternate devices for drum **72** may also be used to reel in/take-up or reel/let out the tether **54** to respectively raise or lower carrier **27**.

As best seen in FIG. **7**, reviewing from right to left, the tether **54** is oriented to frictionally engage several of the lower rods **84**, pass angularly around a portion of the ratchet shaft **74**, through one of a plurality of open spaces **92** formed by pairs of immediately adjacent rods **84**, and then frictionally engage several of the other upper plurality of rods **84** before passing toward the adjacent pulley **64** as generally shown. In operation, rotating the drum **72** about a rotational axis of the ratchet shaft **74** causes the tether **54** to spool or reel on to, or off of, the generally cylindrical-shaped drum **72** thereby respectively raising or lowering the carrier **36**. For example, using the tether **54** threaded through drum **72** as shown in FIG. **7**, from the perspective illustrated in FIGS. **1** and **6**, rotating the drum **72** in a clockwise direction will raise the carrier **27**, and rotating the drum **72** counterclockwise will lower the carrier **27**. Other orientations and engagement methods of tether **54** relative to drum **72** may be used to suit the particular application and desired movement of carrier **36** relative to support member **30**.

Although lifting mechanism **52** is described and illustrated as including a single continuous tether **54** threaded through the ratchet mechanism **56**, alternately, two or more tethers may be used in place of the single tether **54**. For example (not shown), one tether may have a first end attached to the carrier **36** at the first attachment point **59** and a second end attached to one of the rods **84** of the ratchet mechanism **56** (or other reel or take-up device). Similarly, a second tether (not shown) may have a first end attached to the carrier **36** at the second attachment point **61** and a second end attached to one of the rods **84** of the ratchet mechanism **56** (or other reel or take-up device). The lifting mechanism **52** will operate in a similar manner to reel in or out a length of the tether(s) whether employing a single tether or multiple tethers.

Referring to FIG. **10**, an example of a motor **57** is shown. The motor **57** is used to engage and selectively rotate ratcheting mechanism **56** to raise or lower carrier **27**. In the example system **10**, motor **57** is stationarily mounted in a workstation in a position coordinated with a predetermined stopping position for the carrier **27** and workpiece support

beam **36**. For example, when trolley **28** and connected carrier **27** enter a workstation and are brought to a stop at a predetermined position for proper alignment of the carrier **27** and the workpiece **146** for processing at that workstation, for example to be lowered to the trunnion fixture described further below, motor **57** is in alignment for engagement with the ratcheting mechanism **56** in a manner further described below, to raise or lower the carrier **27** as predetermined for that workstation and workpiece **146**. In the examples illustrated herein, workpiece **146** is a passenger vehicle or truck frame. Other automotive components and subassemblies may serve as workpiece **146**. It is understood that workpiece **146** may include other components and subassemblies other than automotive components.

Referring to FIG. **6**, one example of a ratchet mechanism **56** ratchet coupler **104** is shown. Exemplary ratchet coupler **104** includes a pair of diametrically opposed lobes **98** extending radially outward from the ratchet shaft **74** as generally shown. In the example, each lobe **98** includes angularly offset contact surfaces **102** defining diametrically opposed radially-positioned openings **100** between the respective contact surfaces **102**. Referring to FIG. **6**, in one example of a motor coupler (not shown), the motor coupler is connected to motor **57** shaft **96** (FIG. **10**), and includes complimentary lobe structures to abuttingly engage the ratchet coupler **104** such that on rotation of the motor shaft **96**, the motor coupler engages the respective contact surfaces **102** thereby equally rotating the ratchet coupler **104** and the attached drum **72**.

In one example of engagement of the above described motor coupler (not shown), the motor **57**, the motor shaft **96** or other structure (not shown) is actively extended in a direction toward the ratchet coupler **104** to position the motor coupler lobes into the coordinating openings **100** in the ratchet coupler **104** such that rotation of the motor shaft **96** equally rotates the ratchet coupler **104** and drum **72**. On completion of the processing at the workstation, the motor **57**, coupler, shaft **96** or other device is retracted in a direction away from the ratchet coupler **104** to disengage the motor coupler lobes from the ratchet coupler openings **100** thereby clearing the motor coupler from the ratchet coupler **104** so the trolley can freely move from the workstation along the path of travel **21**.

Referring to FIGS. **8** and **9**, an alternate example of a ratchet coupler **104**A is shown. In the alternate example, ratchet coupler **104**A is configured to include a slot **106** defined by walls **116** formed in an end face of the ratchet coupler **104**A opposite the drum **72** so as to be accessible and engageable by the motor coupler **108** (FIG. **10**). Generally centered within the slot **106** is a trapezoidal-shaped cam **110** having sides **120**. The cam **110** is arranged relative to the slot **106** such that a line interconnecting two opposite vertices **112** of the trapezoidal-shaped cam **110** is aligned generally parallel to a longitudinal axis of the slot **106**.

As best seen in FIG. **10**, an alternate motor coupler **108** includes a pair of planar plates **114** spaced for coordinating position between the respective wall **116** of the slot **106** and the cam **110** when the ratchet coupler **104**A engages the motor coupler **108** as described below. The example motor coupler **108** is engaged with the ratchet coupler **104** by horizontally sliding each of the plates **114** of the motor coupler **108** through a respective opening **118** formed in the ratchet coupler **104**A between the side walls **116** and the cam **110** so as to substantially align the motor output shaft **96** with the ratchet shaft **74**. The inclined surfaces **120** of the cam **110** operate to guide and align the motor coupler plates **114** with the side walls **116** of the slot **106** when coupling the two members together.

In one example of engagement of motor coupler **108** and alternate ratchet coupler **104**A, on transfer of a carrier **27** into a workstation, the stationary motor **57** is horizontally aligned, and motor coupler **108** and ratchet coupler **104**A automatically positioned, such that the motor coupler **108** planar plates **114** slidingly enter the ratchet coupler **104**A through the respective spaces **118**. On stopping of the carrier **27** at the predetermined position in the workstation, the planar plates **114** are positioned in abutting engagement, or are directly adjacent to, walls **116** and the motor shaft **96** rotational axis is aligned with the ratchet mechanism shaft **74** rotational axis. On rotation of the motor shaft **96**, the planar plates **114** abuttingly engage the walls **116** causing equal rotation of the ratchet mechanism shaft **74** and the drum **72**. On completion of the processing at the workstation, the motor coupler **108** is automatically returned to its original position, for example, where the planar plates **114** are aligned or parallel with the carrier **27** path of travel **21**, such that on exiting of the carrier **27** from the workstation, the planar plates **114** freely pass through the openings **118** on the other side of the ratchet coupler **104**A to clear the ratchet mechanism **104**A from the motor coupler **108**. Other devices, orientations and methods for aligning and engaging and/or disengaging the described motor couplers from the ratchet couplers **104**, **104**A may be used. It is further understood that different lifting mechanisms **52**, ratchet devices **56** and drive sources such as motor **57** may be used to suit the particular application and performance specifications of the assembly line and system.

In one example of operation of the described motor couplers and ratchet couplers **104**, **104**A, one or more sensors (not shown) are used to monitor and control the rotational positions of one or both of the described motor couplers and the ratchet couplers so that the respective couplers are properly positioned in predetermined alignment as a carrier **27** enters the workstation in order to effect the respective engagement/disengagement scheme described above. For example, encoders may be used in a closed-loop system to monitor the rotational position of the motor shaft **96** and/or the ratchet shaft **74**. In an example where an encoder is used for the motor shaft **96**, the encoder can be in electronic communication, for example wired or through known wireless protocols, with a control system to send signals to the control system as to the present position of the respective shafts and/or couplers. The control system can compare the received current position of the motor shaft **96** (or motor coupler) and send signals to, for example, the motor **57** to ensure the motor coupler is in a position whereby the motor coupler is to properly engage or disengage the respective ratchet coupler **104**, **104**A at the proper point in time of the overall operating system. In one example, the described encoder is placed in communication with the control system previously described and detailed in U.S. Patent Application Publication No. US 2010/0241260. Other sensors, monitors, controllers and control systems may be used.

Referring to the exemplary ratchet mechanism **56** in FIG. **6**, the ratchet mechanism **56** includes a toggle latch **122** operable to prevent unintended movement of the carrier **36** toward the lowered position. The exemplary toggle latch **122** includes a toothed or splined disc **124** having a plurality of teeth **130** fixedly attached to the ratchet shaft **74**. A cantilevered lever **126** may be pivotally attached to the ratchet housing **76**. An end **128** of the lever **126** may intermittingly engage a tooth **130** formed along an outer circumference of the toothed disc **124** to prevent unauthorized rotation of the drum **72** in one particular rotational direction. The toggle latch **122** does not operate to prevent rotation of the drum in an opposite direction. For example, the toggle latch **122** may operate to prevent counter-clockwise rotation of the drum **72** (as viewed from the perspective of FIG. **6**) about ratchet shaft **74** when the lever **126** is engaged with the tooth **130**, thereby preventing lowering of carrier **27**, while also allowing unhindered clockwise rotation of the drum **72**. Counter-clockwise rotation of the drum **72** may be enabled by rotating lever **126** thereby disengaging the lever end **128** from the tooth **130**. The lever **126** may be manually activated or actuated using various mechanical and electro-mechanical actuators (not shown). Sensors (not shown) in communication with a local or centralized control system described above, may be used to monitor the position of latch **122**. Other constructions of toggle latch **122**, for example mechanical clutch or brake devices, to prevent unauthorized rotation, or to permit selected rotation, of drum **74** may be used as known by those skilled in the art.

With reference to FIG. **11**, exemplary inverted carrier lift **10** carrier **27** includes a locking mechanism **132** for securing carrier **27** in the raised position for travel between workstations or for other purposes. The exemplary locking mechanism **132** includes a latch arm **134** pivotally connected to the support member **30** of the trolley **28**. Alternatively, the latch arm **134** may be pivotally mounted to another suitable location on the carrier **27** or trolley **28**. The latch arm **134** reciprocally pivots about a fixed point axis defined by a pivot pin **136** connected to the support member **30** by a bracket **138**. The latch arm **134** may be selectively pivoted between a latched position, as illustrated, for example, in FIGS. **4** and **11**, and an unlatched position, as illustrated, for example, in FIGS. **1-3**. The exemplary latch arm **134** includes a locking pin **140** that may be simultaneously engaged with an aperture **142** in the upper post member **46** and an aligned, coaxial aperture **144** in the lower post member **44** when the carrier **27** is in the raised position. When pivoted to the unlatched position, the locking pin **140** of the latch arm **134** is selectively disengaged from the aperture **142** in the upper post member **46** and the aperture **144** in the lower post member **44**, thereby enabling the carrier to be moved toward the lowered position. The latch arm **134** may be manually, mechanically, electrically, hydraulically, magnetically or pneumatically operated. The latch arm **134** may, for example, be biased, such as by a spring means or the like, towards the latched position. Other constructions or devices for latching, locking or otherwise preventing unauthorized vertical movement of carrier **36** known by those skilled in the art may be used depending on the application and performance specifications.

In examples of an automated latch arm **134**, for example by an electric motor or magnetically powered actuator, the motor/actuator may be connected to a control system having a controller (not shown). The control system would be operable to monitor and/or control actuation or movement of latch arm **134** between a latched and unlatched position through energizing the motor/actuator. One or more sensors (not shown), for example mechanical or electric switches or contacts, or optical/vision systems, may be used to monitor the position of the latch arm **134**. The sensor(s) can also be in electronic communication with the control system to actively monitor the position of the latch arm **134**, for example, a real time, closed-loop automated monitoring and control of the latching mechanism. The control system may include preprogrammed instructions whereby, for example, the motor **57** cannot be energized when the latch arm **134** is determined or sensed to be in a latched or locked position. Equally, conveying system **20**, the lifting mechanism **52** and/or the ratchet mechanism **56** can also include sensors and be in electronic communication with the above-described local or central control system, as well as the respective individual mechanisms and systems, for a semi-automated, or fully automated, closed-loop operation for system **10**.

In one example of inverted carrier lift system **10** shown in FIGS. **1-5**, the workstation may include a trunnion mounted fixture **148** for engaging and supporting the workpiece **146** during a processing operation at the workstation. In the example illustrated, the trunnion fixture **148** includes a rotatable frame **150**, a trunnion **152** connected to the frame **150** for rotation therewith, and a drive **154**, for example a rotary drive motor. The trunnion **152** may be supported by multiple rollers **156** mounted to a base **158**. The drive **154** selectively rotates the trunnion **152**, the frame **150** and engaged workpiece **146** reciprocally through a predetermined angular movement by rotatably driving the trunnion **152** relative to the base **158** about an axis of rotation for end plates **160**, **162**.

In the example trunnion **152**, two circular, generally disc-shaped end plates are used for engaging workpieces **146**, including a first end plate **160** and a second end plate **162**. The frame **150** includes one end **164** connected to the first end plate **160** and a second end **166** connected to the second end plate **162**. The frame **150** and/or the end plates **160** and **162** may support clamps, tooling, fixtures, engagement pins, sensors and other devices for receiving, positioning and/or temporarily securing the workpiece **146** to the trunnion **152**, for example to the frame **150**, during processing of the workpiece **146**. The workpiece **146** may be supported by the trunnion fixture **148** between the end plates **160** and **162**. For example, the workpiece **146** may be transferred to the trunnion fixture **148**, as shown, for example, in FIGS. **1** and **2**.

One or more workpiece engaging devices (not shown) may be connected to and positioned relative to the frame **150** and/or the end plates **160** and **162**. The workpiece engaging device may include a tooling, nesting or holding fixtures, locating pins, clamps, and other devices for guiding, positioning, engaging and/or securing the workpiece **146** to the trunnion fixture **148**. Both the first end plate **160** and the second end plate **162** may be fitted with similar workpiece engaging devices, or with different configurations or operative devices. Electric or pneumatic power and/or controls for the workpiece engaging devices, or for other structures of the trunnion fixture **148**, may be directed through an aperture **168** in the end plates **160** and **162** or by other devices or structures. Control of the exemplary workpiece engaging devices may be actively monitored and controlled by the control systems, devices, hardware and/or software in a manner previously described, for example described in U.S. Patent Application Publication No. US 2010/0241260. Other devices and methods of monitoring and controlling the position and actuation of workpiece engagement devices, either locally by the workstation, or centrally in the plant facility, may be used.

In one example of inverted carrier system **10**, one or more workpiece engaging devices **147** are connected to the workpiece support beam **36** and/or auxiliary arms **50** (as shown) to removably engage and secure the workpiece **146** to the carrier **27**, for example, workpiece support beam **36**. In one example, on transfer of the workpiece **146** to the trunnion fixture **148** for workstation processing, the one or more workpiece engaging devices **147** are disengaged or otherwise, for example by an actuator (not shown), to release the workpiece **146** from the workpiece support beam **36** and/or the auxiliary arms **150**, or otherwise the carrier **27**.

In one example, none of the carrier **27**, lift mechanism **52**, or trolley **28** includes an onboard power generation devices or control systems that require a power connection to operate. For example, as illustrated and described above, lifting mechanism **52** does not require an onboard electrical motor to rotate drum **72** which would require a power connection or hook-up when the carrier **27** is positioned in the workstation. Rather, ratchet mechanism **56** is configured to be engaged by an electrical motor **57** which is stationarily mounted in the workstation. This is advantageous to reduce complexity of the system **10** and carrier **27**. A further advantage is shorter cycle times through a reduced number of, or no required, connections of power to the trolley **28** and/or carrier lift **27** when the trolley **28** enters and exits a workstation.

In one alternate example (not shown), remote power or signals may be used in order actuate actuator(s) (not shown) for the above-described workpiece engaging devices **147** mounted on the workpiece support beam **36** in order disengage/engage the workpiece **146** for transfers between the carrier **27** and the trunnion fixture **148**. For example, clamps (not shown) positioned on workpiece support beam **36** used to engage workpiece **146** may require electrical or pneumatic power to actuate the clamps between an open (typically disengaged position) and a closed (typically engaged) position. In one example, on the carrier **27** positioning of the workpiece **146** in the desired position, for example a fully lowered position thereby placing workpiece **146** in the proper position on trunnion fixture **148**, cooperating and mating power connection modules or connectors are used on both of carrier **27** and the trunnion fixture **148** or the workstation. For example, as described above, the trunnion fixture **148** includes a power source (for example, electrical wiring harness or pneumatic tubing and valves with an end connector/module/plug/coupling) that may extend through aperture **168**. Trunnion fixture **148** may further include a connector module, plug, socket or connector block vertically positioned in the lowering travel path of the carrier **27**, for example the path of the horizontal member **48** and/or auxiliary arms **50**. The carrier **27**, for example workpiece support beam **36**, can also include a coordinating and mating power connector/block/socket/plug/coupling that is aligned with the connector/block on the trunnion fixture **148**.

On lowering of the carrier lift **27** to a position where the workpiece **146** is properly positioned on the trunnion fixture **148** for processing, the coordinating power modules/blocks on the carrier **27** and trunnion fixture **148** engage thereby completing a power circuit to provide power to the carrier **127** workpiece engaging devices to disengage the workpiece **146** from the carrier **27** such that the trunnion fixture **148** fully supports the workpiece **146** for further processing. On completion of the workstation processing on workpiece **146**, the carrier **27** may be re-lowered into position such that the coordinating/mating power modules/blocks re-engage thereby providing power (for example electrical, data, pneumatic) to the workpiece engaging devices **147** on the carrier **127** to re-engage the workpiece **146** and remove the workpiece **146** from trunnion fixture **148** so that the carrier **127** may be transferred to a subsequent workstation for further processing. This example is advantageous as described above due to reduced equipment and complexity of mobile carrier **27**.

In one example, the workpiece engaging devices connected to the trunnion fixture **148** may be powered and operated in a similar manner through the supply of power previously described. Monitoring, actuation and control of the workpiece engaging devices may be made through communication of such devices, or sensors in communication with the devices, by a local or central control system previously described and detailed in U.S. Patent Application Publication No. US 2010/0241260. Other devices and processes to engage/disengage the workpiece **146** from the carrier **27** and/or provide power to the carrier **27** and/or trunnion fixture **148** may be used.

In the example trunnion fixture **148**, the end plates **160** and **162** are rotatably supported and frictionally engaged on the rollers **156** to promote selected rotational movement of the frame **150** and the end plates **160** and **162** about a longitudinal axis of the trunnion mounted fixture **148**. In one example, an outer circumferential edge **170** of each roller **156** engages an outer circumferential edge **172** of the respective end plates **160** and **162**. Each roller **156** may be rotatably connected to a bracket **174** fixedly attached to the base **158**. Rotation of the rollers **156** causes a corresponding rotation of the respective end plates **160** and **162** about the longitudinal axis of the trunnion mounted fixture **148**. The rollers **156** are suitably configured for supporting the weight of the end plates **160** and **162**, the frame **150** and the workpiece **146** connected to the trunnion mounted fixture **148**.

The respective outer circumferences **170** and **172** of the rollers **156** and end plates **160** and **162**, respectively, may include mating contours to help minimize axial movement of the trunnion **152** relative to the rollers **156**. For example, the outer circumference **170** of the rollers **156** may include a recessed groove **176** that rollingly engages a corresponding convex shaped outer circumference **178** of the end plates **160** and **162**. Other contours may also be employed. The outer circumferences of the rollers **156** and the end plates **160** and **162** may employ or include materials configured to enhance traction between the rollers **156** and the end plates **160** and **162**. In one example, the rollers **156** may be made of urethane to promote frictional contact with the end plates **160** and **162**. Other materials and methods of engagement may be used. Other constructions and methods for preventing or minimizing relative axial movement between the end plates **160** and **162** and rollers **156** may be used by those skilled in the art.

With continued reference to FIGS. **1** and **3**, the exemplary drive **154**, for example the rotary drive motor illustrated, is operable to rotatably drive at least one of the rollers **156** (powered rotation of both end plates **160**, **162** shown in FIG. **2**) and rotate the trunnion **152** about its longitudinal axis. The drive **154** is fixedly attached to the base **158**. A drive shaft **180** (two shown) is rotatably coupled at least one of the rollers **156** to the rotary drive **154**. The exemplary drive shaft **180** includes one or more universal joints **182** (two shown per drive shaft **180**) to accommodate any misalignment between an output shaft **184** of the rotary drive **154** and an input shaft **186** of the roller **154**. Multiple drive shafts **180** may be employed to drive multiple rollers **154**. For example, in the illustrated exemplary configuration, a first drive shaft **188** is used with output shaft **184**, input shaft **186** and two universal joints **182**, to rotatably connect the rotary drive **154** to a roller **156** engaging the first end plate **160** and a second drive shaft **190** is similarly rotatably connected to the rotary drive **154** to a second roller **156** engaging the second end plate **162**. This particular configuration enables the rotary drive **154** to supply rotary power to both end plates **160** and **162** to rotate the trunnion **152**. It is not necessary, however, that both endplates **160** and **162** be rotatably driven by the rotary drive **154**. In practice, one or both end plates **160** and **162** may be rotatably driven by the rotary drive **154**. It is understood that other drive devices **154** other than a rotary drive motor may be used.

In operation, the drive **154** may rotate the trunnion fixture **152** in either rotational direction, as indicated by arrow **192** in FIGS. **1** and **2**. With particular reference to FIG. **3**, the rotary drive **154** may include a motor **192**, which may be an electric motor, a hydraulic motor, pneumatic motor, or another suitably configured motor or source of power convertible to rotational movement at the end plates **160**, **162**. The rotary drive **154** may further include a gear set configured to tailor the output torque and rotational speed of the rotary drive output shaft **184** to accommodate the design and performance requirements of a particular application.

With reference to FIG. **12**, an alternate example of the rotary drive **154**A is shown. In the example, rotary drive **154**A is configured to rotatably drive two or more rollers **156**A that each engages a common end plate. In the exemplary configuration illustrated in FIG. **1**, the rotary drive **154**A is configured to drive a single roller **156** engaging the first end plate **160** and a second roller **156**A engaging the second end plate **162**. To help maximize transfer of rotational torque from the rollers **156**A to the end plates **160** and **162**, multiple rollers **156**B may be rotatably interconnected, for example, by a belt **196**. This arrangement causes the rotatably interconnected rollers **156**A, B to rotate substantially in unison and rotate the trunnion fixture **152** about its longitudinal axis. Alternatively, the rollers **156**A, B may be rotatably interconnected by a chain, a gear set, or another device suitable for transferring rotational torque between multiple rotary devices.

In the FIG. **12** example, the belt **196** operates to transfer rotational torque delivered to a first roller **156**A from the rotary drive **154** to a second roller **156**B. Rotatably interconnecting multiple rollers **156**A, B reduces the amount of rotational torque transferred from each individual roller to the respective end plates **160** and **162**, thereby reducing the tractive force between the rollers **156**A, B and the end plates **160** and **162** required to rotate the trunnion **152** without slipping. In the FIG. **12** example, the rollers **156**A, B that engage the first end plate **160** are rotatably interconnected by the belt **196**, and the rollers **156**A, B engaging the second end plate **162** are rotatably interconnected by a second belt **196**. In practice, it may not be necessary that rollers **156**A, B at both ends of the trunnion **152** be rotatably interconnected.

In one example of rotary drive **154** not shown, a separate rotary drive **154** may be employed to separately drive the rollers **156** associated with each end plate **160** and **162**. For example, with reference to FIG. **13**, the rotary drive **154**B may be rotatably connected to a single roller **156**C rotatably associated with the first end plate **160**. Where both end plates **160** and **162** are rotatably driven, a second rotary drive **154**B may be used to rotatably drive a second roller **156**C associated with the second end plate **162**. As mentioned previously, the two or more rollers **156** associated with the same end plate may be rotatably interconnected by a separate belt **196**.

In an alternate example of rotary drive **154** shown in FIG. **14**, two or more rollers **156**D may be rotatably interconnected for rotatably driving the trunnion fixture **152**. For example, in the exemplary configuration illustrated in FIG. **14**, four rollers **156**D are used to rotatably drive the trunnion fixture **152**. Each roller **156**D may be rotatably interconnected to an adjacent roller **156**D by the belt **196**, or another suitable connection device as previously described or known by those skilled in the art. Any one of the four rollers **156**D may be rotatably connected to rotary drive **154**C through a drive shaft **198**. Rotary torque output from the rotary drive **154**C may be transferred to the roller **156**D directly connected to the rotary drive **154**C by drive shaft **198** and to adjacent rollers **156**D by the corresponding belts **196**. In the illustrated exemplary configuration, all four rollers **156**D engaging the end plate **160** are rotatably interconnected, but in practice it may not be necessary that all rollers **156**D engaging a particular end plate be rotatably interconnected. A similar rotary drive arrangement, in which multiple rollers **156** are rotatably interconnected, may also be employed with the rotary drive **154**C used to simultaneously drive both end plates **160** and **162**, as illustrated for example, in FIG. **1**.

In one example of described rotary drives **154**, for example as illustrated in FIGS. **1**, **13** and **14**, the rotary drive is connected to a controller **210**. Controller **210** is in electronic communication with the control system previously described for active monitoring and actuation by the control system for a semi or fully-automated, closed loop system through one or more sensors previously described. Other devices and methods to monitor and control rotary drive **154** may be used. Other sensors in communication with the controller **210** and previously described control system may be used with system **10**. For example, a sensor (not shown) may be used to determine when workpiece **146** is in a predetermined and proper position with the trunnion **154** such that rotary drive **154** can be properly and automatically energized to rotate the workpiece to a predetermined position for assembly operations at that particular workstation.

It is further understood that the described workstation and process may not be an assembly or manufacturing workstation or area, but an alternate predetermined area along the assembly line path of travel **21** which serves as a temporary storage area or holding area for workpiece **146** (each considered a workstation for simplicity in this disclosure). For example, the workstation may be a production line buffer wherein workpieces that are in process are temporarily stored or racked until needed for the next stage of the assembly or manufacturing process.

Although shown as a trunnion fixture **148**, different fixtures, tooling, racks and other movable and fixed devices suitable for supporting and securing workpiece **146** may be used (each referred to as a "fixture" for simplicity herein). For example, the fixture may be an indexing storage rack for temporarily holding a plurality of workpieces, for example in an in-process buffer area or an end-of-process storage area where completed parts await packaging and shipment. Other fixtures suitable for the particular workstation or process operation known by those skilled in the art may be used.

With reference to FIG. **1**, a sensor **200** may be employed to monitor the rotational position of the trunnion **152**. A suitable example for sensor **200** includes an encoder in communication with a closed loop control system as previously described for motor shaft **96**, which precisely measures and monitors the rotational movement and position of an end plate **160**,**162**.

With reference to FIGS. **1**, **13** and **14**, the controller **210** may be operably coupled to the sensor **200** and the rotary drive **154**. The controller **210** may be configured to control rotation of the trunnion **152** through operation of the rotary drive **154**. The final position of the carrier **36** in the workstation may also be determined by the controller **200** operating in conjunction with sensors in communication with the overhead conveyor system **20**. The controller **210** may also control the rotary drive **154** to rotate the trunnion **152** in response to various inputs, for example, that the workpiece **146** has been placed in the trunnion mounted fixture **148** and is ready for processing, or that processing is completed and the workpiece **146** may now be oriented for reattachment to carrier **36** of the overhead conveyor system **20**. The controller **210** may also communicate with a robot (not shown) configured to perform a processing operation on the workpiece **146** attached to the trunnion mounted fixture **148**, and the carrier **27** moving along the guide rail **22**. As previously described, the described trunnion fixture **148**, rotary drive **154**, and carrier **27** equipment described may individually, or collectively, be in electronic communication with a local and/or centralized control system, for example that described in U.S. Patent Application Publication No. US 2010/0241260, for active monitoring, actuation and control according to preprogrammed instructions through sensors and signals to, and from, inverted carrier lift system **10**.

With reference to FIGS. **1-4** and **11**, the carrier **27** may be moved along the guide rail **24** and is controllable to stop at a workstation by appropriate switches and/or sensors and control circuitry. In one example, the previously described control system executes preprogrammed instructions to the conveyor **20** to position and stop the carrier lift at a predetermined position at the workstation. In one example, optical sensors positioned at the workstation read a coded strip in a closed loop feedback system to precisely position the carrier lift at a predetermined position at the workstation along the path of travel **21**. One suitable example is described in U.S. Pat. No. 7,108,189.

The carrier **27** supports at least one workpiece **146** during movement of the carrier **27** along the guide rail **24** with respect to the workstation. The carrier **27** may be alternately moved between the raised position, as illustrated, for example, in FIG. **4**, and the lowered position, as illustrated, for example, in FIGS. **1-3**, when positioned at the workstation. The locking mechanism **132** (FIG. **11**) is provided for securely maintaining the carrier **27** in the raised position with respect to the trolley **28** when the latch arm **134** is arrange in the locked position, as illustrated, for example, in FIGS. **4** and **11**. The locking mechanism **132** enables movement of the carrier **36** to the lowered position when the latch arm **134** is in the released position, as illustrated for example, in FIGS. **1-3**.

As previously described, in one example the carrier **27** is slidably associated with the trolley **28** so as to be moveable vertically in relation to the trolley **28** to lower the workpiece **146** into the workstation, and more particularly, the trunnion mounted fixture **148**, without the necessity of lowering the entire overhead conveyor system **20**, as with some prior known mechanisms. In one example, the workpiece **146** is released or disengaged from horizontal member **48** and arms **50** through release of clamps or other workpiece engaging devices **147** connected to horizontal member **48** and auxiliary arms **50** in engagement with workpiece **146**. The clamps or other retaining devices may be electronically connected to and controlled by the local or centralized control system including sensors previously described above.

The workpiece **146** may be retained within the trunnion **152** by one or more workpiece retaining devices previously described. Once secured to the trunnion mounted fixture **148**, the workpiece **146** is ready for processing, which may include, for example, rotating the workpiece on one or more positions, for one or more welding operations or a metal forming operation designated for that workstation. For example, one or more robots (not shown) may perform a welding operation on the workpiece **146** supported by the trunnion mounted fixture **148**. In one example, the trunnion **152** may reposition the workpiece **146** to another position following a process. For example, following one welding operation at the workstation, the workpiece may be rotated to another position so that a second welding operation can occur allowing better access by the second welding robot.

When processing of the workpiece **146** is complete, the trunnion **152** may be rotated by the rotary drive **154** to a predetermined rotary position in preparation for removal from the trunnion mounted fixture **148** by the carrier **27**. The controller **210** or the local or centralized control system previously described may then control the carrier **27** to engage the workpiece **146** to the carrier **36** and remove the workpiece **146** from the trunnion mounted fixture **148**. On completion of the predetermined operations at the workstation, the motor **57** (FIG. **10**) may be selectively actuated to raise the carrier **27** and the now more complete workpiece **146** back to raised position for transport to another location within the manufacturing facility. When all operations at the workstation are complete, the overhead conveyor **20** may be actuated and the carrier **27** moved along the path of travel **21** out of the work station.

Referring to FIGS. **14-30**, an alternate example of carrier lift device **10** in the form of carrier lift **310** and methods of use are shown. Where identical or like components are disclosed and/or illustrated in prior figures, the same reference numbers are used and not further described except where noted. Where minor modifications exist, or for purposes of simply distinguishing different versions of the same device, capital letters, A, B, C or D may be used. Alternately, the same base number with a higher number by one-hundred, two hundred or three hundred may be used. Where like components include the same or similar constructions and/or functions, the same names are used although different reference numbers may be assigned.

Referring to FIGS. **15**, **16** and **25**, an example alternate carrier **310** is shown. In the example, carrier **310** is shown in an exemplary use for supporting and transporting vehicle components or other workpieces **146** previously described, progressively assembled in a plurality of sequential workstations **314** along an assembly line **316** defining a path of travel **21** by the carrier **310**.

The exemplary carrier lift **310** is preferably includes trolley **28** engaged with an elevated or overhead conveyor **20** for movement of the trolley **28** and carrier along an assembly line path of travel **21** as previously described for alternate carrier **10**.

Still referring to FIGS. **15** and **16**, the exemplary carrier lift **310** and carrier **27**A further includes an exemplary platform **346** and a workpiece support beam **350** having an upper surface **349** and lower surface **351** as generally shown. In an alternate example of support beam **36**, carrier **27**A includes support beam **350** which can be of the same or similar construction as workpiece support beam **36** as previously described and illustrated in FIG. **2** (collectively referred to as “workpiece support beam” or “support beam”). Referring to FIG. **2**, an alternate example of support beam **350** (not shown) includes two pairs of extension members or arms **50** transversely extending from beam **350**. Arms **50** may be selectively connected to, or be integral with, support beam **350** to suit the specific application and workpiece **146** to be supported and conveyed along assembly line path of travel **21**.

In a preferred example, support beam **350** and arms **50**, or other attachment and workpiece engaging devices, are modular in nature and can be quickly connected and disconnected to support beam **350** to quickly change the support beam **350** configuration to, for example, accommodate different components or vehicle styles to support dynamic random build sequences (vehicle models A, C, D, B, E), or batch build assembly sequences (vehicle models AAA, BBB, CCC, DDDD). Although shown as straight bars, support beam **350** and extensions **50** can take other forms, shapes and configurations to suit the particular application as known by those skilled in the art. Respective rails **30**, beams **350** and arms **50** are preferably made from aluminum or steel but can be made from other materials known by those skilled in the art. It is further understood that support beam **350** can include workpiece engagement devices **147** as previously described (not shown in FIGS. **15-30**) to selectively, securely and releasably engage various workpieces **146** in the manner and operation generally described for carrier lift **10**. For example, pneumatic clamping devices which are actuated through pressurized airlines may be used to clamp and hold a workpiece **146** until a control system actuates the clamps to release component **146** as generally described above. Other engagement devices, mechanisms and ways to control them known by those skilled in the art may be used.

Referring back to FIGS. **15** and **16**, exemplary carrier lift **310** and carrier **27**A includes an alternate lift mechanism **352**. In the example, lift mechanism **352** includes two telescopic posts **338** having similar construction and function as telescopic posts **38**, including a lower post member **344** and an upper post member **345** movable along an axis of travel **370**, similar to lower post member **44** and upper post member **46**, as generally described above. A stop (not shown) may be included to prevent overextension of telescopic posts **338**, for example, lower post member **344** extending too far and disengaging from upper post member **345**. Telescopic rods **338** may include other devices within upper post member **345** to assist in the control and movement of lower post member **344**, for example, bushings, bearings and/or other devices as known by those skilled in the art. Other constructions, configurations and positioning of telescopic posts **338** with respect to support member **30** and support beam **350** may be used as known by those skilled in the art.

In the example carrier lift **310** carrier **27**A shown in FIG. **15** each telescopic post **338** includes a brace **373** connected to support member **30** and upper post member **345**. In one example, brace **373** assists to keep the respective post **360** in a vertical orientation and may further prevent or reduce rotation and/or linear movement in the geometric X direction (along path of travel **21**) or along the geometric Y direction (transverse to path of travel **21**). Other devices and mechanisms to prevent or reduce rotation (rocking) or linear movement of the lift mechanism **352** relative to the overhead conveyor **20** may be used as known by those skilled in the art.

Referring to FIGS. **17-19**, and **26-30** alternate examples of carrier **310**, carrier **27**B and lift mechanism **352**A are shown. Referring to FIGS. **17** and **18**A and **18**B, carrier **27**B and lift mechanism **352**A alternately employs a scissor-type lift mechanism **426**. In the example, scissors lift mechanism **426** includes a first link **430** (two shown) and a second link **436** (two shown) respectively connected to support member **30** and workpiece support beam **350** and each other at pivot points **440** as generally shown. First **430** and second **436** links rotate about pivot points **440** to raise to position the support beam **350**, platform **346** if used, between a raised position **410** shown in FIG. **18**A and a lowered position **416** as shown in FIG. **18**B through a lift mechanism drive **355** further described below.

In the example carrier **27**B and lift mechanism **352**A shown in FIGS. **17** and **18**A and **18**B, the links **430** and **436** are positioned inward toward each other. In the alternate lift mechanism **352**B and carrier **27**C example shown in FIG. **19**, the links **430** and **436** are positioned outward and away from each other as generally shown (FIG. **19** showing the carrier **310** in both the upper position **410** (in phantom line) and the lower position **416** (solid line). The alternate positioning and/or configuration of scissor links **430** and **436** provide flexibility and packaging of the carrier lift **310** and carrier **27**B and C to suit and better accommodate the assembly process, workpiece **146** (not shown), assembly tooling (not shown), other equipment (not shown) positioned in the workstation **314** or along assembly line **316**, or the assembly predetermined assembly process. Links **430** and **436** are preferably made from aluminum or steel, but may be made from other materials suitable for the application and performance specifications as known by those skilled in the art. Although shown as using two links **430** and **436**, it is understood that a different number of links and/or alternate configurations of links known by those skilled in the art may be used.

The example carriers lifts **310** and carriers **27**A, B and C shown in FIGS. **15**-**19** further include an alternate lift mechanism drive **355** used to power and control the movement of workpiece support beam **350**, platform **346** (if used), and workpiece **146** if connected thereto along the travel axis **370** described above. Example lift mechanism drive **355** includes an electrical motor **357** preferably directly engaged with a drum **372** which is engaged with an elongate tether **354**. Tether **354** is similar in construction, and alternative constructions, as described above for tether **54**. A ratchet mechanism **356** is not preferred due to the direct engagement of the motor **357** to the drum **372**, but may be used where an application or performance requirements dictate use.

Referring to the example carrier lift **310** and carrier **27**A shown in FIGS. **15** and **16**, exemplary elongate tether **354** is connected at a first end **358** (to the left in FIG. **16**) to the support beam **350**, continuously extends upwardly and coaxially through telescopic rod **338**, over a pulley **406**, through drum **376**, over a second pulley **406** and downwardly through the other telescopic rod **338** to connect to support beam **350** at a tether second end **360**. As described above, or in the alternative, tether **354** may be a chain, braided cable, belt or other device suitable for the application as known by those skilled in the art. As described above for tether **54**, although shown as a single tether **354**, more than one tether **354** may be used per lift carrier **310**.

Referring to the example carrier lift **310** and carrier **27**B shown in FIGS. **17**-**19**, exemplary elongate tether **354** is connected at the first end **358** (to the left in FIG. **17**) to the support beam **350**, continuously extends upwardly over the pulley **406**, through drum **376**, over a second pulley **406** and downwardly to connect to support beam **350** at the tether second end **360**. In exemplary operation, on energizing motor **357**, drum **372** rotates so as to increase or decrease the length of tether **354** between the motor **357** and first **358** and second **360** tether ends to respectively lower or raise support beam **350** and workpiece **146** if connected thereto. In one example, drum **372** selectively spools out tether **354** to increase the effective length between attachment points **358** and **360** to lower support beam **350** or gathers and winds tether **354** to decrease the effective length of tether **354** to raise support beam **350** and workpiece **146** if connected thereto.

Referring back to FIGS. **6** and **7**, in one example, carrier lift **310** lift mechanism **352** may include a ratchet mechanism **356** connected to drum **376** in a similar construction and manner as previous described for alternate lift mechanism **52**, ratchet mechanism **56** and drum **72** as previously described. In the exemplary carrier lift **310** and carrier **27**A or B, tether **354** is engaged with drum **372** in a similar manner, and in similar alternatives, as previously described for carrier lift **10**. In the alternate lift mechanism **352** shown in FIGS. **15**-**19**, motor **357** is connected to support member **30** as opposed to being separate from carrier **310** and stationarily mounted in the workstation as described for carrier lift **10**. In one example, motor **357** engages ratchet mechanism **356** to selectively rotate ratchet mechanism **357** and drum **372** to take up or gather a length of tether **354** around drum **372** to raise support beam **350**, or to let out or unspool a length of tether from drum **354** to lower support beam **352** to a lowered position **416**, or any position along the axis of travel **370**. A toggle latch **122** is used to prevent unauthorized rotation of drum **372** raising or lowering of tether **354** as described above for carrier lift **10**. Other devices, and alternatives, described for carrier lift **10** may be used for alternate carrier **310**. As noted above, in a preferred example, ratchet mechanism **356** is not used and motor **357** is engaged directly with drum **372**.

In the example lift carrier **310** and carrier **27**A-D shown in FIGS. **15**-**19** and **26**-**30**, wherein the motor is connected to support member **30** or is "onboard" carrier **27**A-D, motor **357** can be a common electrical motor with a rotating output shaft (not shown) engaged with the ratchet mechanism **356** and drum **372** as previously described. Alternately, motor **357** may be a pneumatic motor, a linear motor, an inductive motor, or other motor as known by those skilled in the art. An electrical power source to the motor **357** may also be onboard carrier **310** or connected to, for example, support member **30** and provide continuous electrical power to motor **357**. Alternately, electrical power may only be supplied to motor **357** when carrier **310** arrives and is properly positioned in workstation **314**, for example, coordinating electrically conductive contact plates or induction devices which complete an electrical circuit between carrier **310** and workstation **314**. Other devices and methods of establishing electrical power to motor **357** known by those skilled in the art may be used. Equally, other service lines, for example pressurized air, electronic and/or data communication between the workstation **314** and carrier **310** may be employed such that the exemplary service lines are automatically connected on arrival and positioning of carrier **310** in a workstation **314** to power, for example, motor **357** and workpiece engaging devices **147** connected to support beam **350**. For example, pressurized air may be used to actuate clamps positioned on support beam **350** to engage workpiece **146**. Alternately, on sensing or detecting carrier **310** is positioned at a workstation **314** or other predetermined location along path of travel **21**, actuators may activate and physically connect the service lines allowing communications of electrical power, data, pneumatic, hydraulic and other service lines between workstation **314** and carrier **310**.

For example carrier lifts **10**, **310**, a centralized controller (not shown) connected to, or onboard, carrier **310** may be in communication with other controllers or actuators onboard carrier **310** to execute signals which energize or actuate motor **357** and workpiece engaging devices **147**. The carrier **310** central controller may be in communication, for example hard wire or wireless protocols, with a local workstation or assembly line controller or an assembly plant programmable controller to send and receive signals, data and/or instructions to actuate the motor **357** and workpiece engaging devices **147** in a predetermined sequence as generally described above or described herein. Equally, sensors (not shown) may be included for motor **357**, workpiece engaging devices **147** and other equipment connected to carrier lift **310** to actively monitor, in a closed loop feedback system, the precise position and/or operations status of the respective equipment and send signals to the local or centralized assembly plant controllers and control system as previously described for carrier lift **10**. The previously mentioned controllers and control systems may each include a central processing unit (CPU), memory storage devices for storing preprogrammed instructions and received signals and/or data, transmitters, receivers, input and output devices, and buses to place the respective components in communication with each other. Other devices for the described controllers and control system known by those skilled in the art may be used.

Referring to FIGS. **20** and **21**, an example application and method of use of carrier lifts **10**, **310** and carrier **27**A, B or C (**27**C shown) in an assembly line **316** with two sequential workstations **314**A and **314**B along the path of travel **21**. In the example, first station **314**A is set up to be a manual load inspection station including an elevated work table **508**. In one example, work table **508** serves as an area where operators can conduct manual placement of components on the table **508** for manual assembly operations or to simply position the components in holding fixtures or other tooling for further processing or assembly. In one example, work table **508** includes a grid of precision through holes **509**, for example every 100 millimeters (mm) in an X and Y coordinate direction, wherein precision tooling or fixtures are secured for accurate and precision positioning of workpieces **146** for further processing. See for example the platform or table **346**/**508** shown in FIG. **24**.

As best seen in FIG. **21**, carrier lift **10**, **310** (**310** shown) and carrier **27**A, B or C (C shown) and workpiece support beam **36**, **350** is positioned in a raised position **410** at an upper level **500** while table **508** is positioned on a lower level **506** of the exemplary scaffolding or frame structure. On completion of the work by the operators in workstation **314**A, lift mechanism **52**, **352** can be energized and workpiece support beam **36**, **350** can be lowered to a lower position **416** to the lower level **506**, wherein workpiece engaging devices **147** are actuated to engage one or more workpieces **146** positioned on work table **508**. Lift mechanism **52**, **352** can them be energized to raise support beam **36**, **350** with engaged workpiece(s) **146** to a higher or raised position **410** along travel axis **370** and then moved down to the next workstation **314**B for further processing. In one example, workpieces **146** are loaded onto work table **508** by devices other than carrier lift **10**, **310**, for example programmable robots or human operators wherein carrier lift **10**, **310** then engages the workpieces and raises carrier **27**A, B or C in the manner described.

In the example, workstation **314**B is an automated work station which may include, for example, a plurality of programmable multi-axis robots (not shown) to further conduct assembly operations on the progressively assembled workpiece **146**. In the example workstation **314**B, carrier lift **10**, **310** and carrier **27**A, B or C (C shown) may lower support beam **36**, **350** and engaged workpiece **146** to a lowered position **416** to the workstation lower level **506**, or to another elevation along travel axis **370**, into what is schematically shown as a tooling area **420**.

Tooling area **420** may be an area of the workstation which contains holding or welding fixtures, for example trunnion fixture **148** or other fixtures, tooling or supports described herein, which secure workpieces **146** in a predetermined position so that, for example, spot welding by the industrial robots can take place. In one example, lift mechanism **52**, **352** selectively, for example through control signals sent by a local or central control system as described above, lowers the workpiece **146** onto the fixtures or other tooling in tooling area **420** and then disengages the workpieces **146** in a manner previously described by workpiece engaging devices **147**, and then is raised to so as to be clear of the travel paths of the robots so the predetermined assembly or manufacturing work can take place.

On completion of the predetermined work in workstation **314**B, in a preferred example, the carrier **27**A, B or C positioned above the workpiece **146**, rises and returns to workstation **314**A to engage a new or next workpiece positioned in workstation **314**A, rises and delivers the next workpiece in workstation **314**B. The completed workpiece in workstation **314**B is retrieved by a second carrier lift **10**, **310** positioned in a subsequent workstation positioned downstream along path of travel **21** to retrieve the workpiece from workstation **314**B and deliver it to the next downstream workstation (not shown) along path of travel **21**. This process continues with the carrier lift **10**, **310** moving only between workstations **314**A and **314**B as the workpiece progressively moves down path of travel **21**.

Alternately, carrier **10**, **310** positioned in workstation **314**B may be lowered, re-engage workpiece **146** in the manner previously described, and through overhead conveyor **20** and trolley **28** move along the path of travel **21** downstream to the next workstation in assembly line **316** (not back to workstation **314**A as described above). In one example as shown in FIG. **21** workstation **314**B, on raising the carrier **10**, **310** to upper level **500**, further manual operations may take place prior to carrier **10**, **310** moving along path of travel **21** to the next workstation. It is also understood that on completion of work in workstation **314**B, the carrier lift **10**, **310** may be moved back to workstation **314**A with original workpiece **146** for more assembly or process work in a cyclical manner back and forth between two or more workstations to suit the particular application.

Although workstation **314**A and **314**B are described as being manual and automated assembly setups and functions, it is understood that the workstations may be reversed in order, for example automated assembly first then manual operations, or may be a combination of both manual and automated operations in the same workstation depending on the application. It is further understood that different operations may occur than those described. For example, automated robots (not shown) may grasp and position workpiece **146** and place them in tooling fixtures in workstation **314**A instead of manual operations depending on the application.

An advantage of carrier lift **310** carriers **27**A, B and C and workpiece support beam **350** is that support beam **350** may be used to engage workpieces **146** on the support beam **350** underside or lower surface **351** (similar to support beam **36** previously described) or on the support beam **350** upper surface **349**. When engaged on lower surface **351**, for example as shown in FIG. **1** for carrier **10**, carrier **310** can then lower and place the workpiece **146** into awaiting fixtures, for example trunnion fixture **148**, and/or tooling positioned in the tooling area **420**. Alternately, and with an advantage of process flexibility, when advantageous to engage and position a workpiece **146** in an upward facing orientation on support beam **350** upper surface **349**, or a support platform **346** shown in FIG. **15**, this facilitates alternate operations, for example manual assembly workstations.

Referring to FIG. **22** an example of an application for carrier lift **10**, **310** and carriers **27**A, B and C (C-shown) is shown for use with a vertical workpiece storage stacker or buffer **510** positioned along path of travel **21**. In the example, a workpiece stacker **510** includes a cradle or component dunnage **516** positioned in a workstation at a lower level **506**A, for example a tooling area **420** described above. In the example, partially assembled or completed workpieces **146** are vertically stacked or oriented pending further assembly processing or packaging and shipping. This stacking may occur anywhere along an assembly line **316** path of travel **21**, for example at the beginning of an assembly line where workpieces **146** are stored awaiting introduction to an assembly line or at the end of an assembly line waiting to be transferred to the next assembly line. Alternately, for example, a mid-assembly line buffer area is needed in the event a downstream assembly line is temporarily halted or shut down allowing the upstream assembly line to continue operating.

In the example, a plurality of workpieces **146** are vertically stacked as generally shown. Carrier lift **10**, **310** is positioned in the workstation **316** at an upper level **500**A or raised position **410** and then lowered through lift mechanism **52**, **352** to engage the exposed workpiece **146** through, for example, actuation of workpiece engaging devices **147** as generally described above. Carrier **10**, **310** is then raised by lift mechanism **52**, **352** as described above and moved to the next workstation down the assembly line path of travel **21**. Alternately, carrier **10**, **310** may be used to place or deposit workpieces **146** into the stacker **510** and cradle **516** in a similar manner as placing workpieces in a fixture, for example trunnion fixture **148**, as described above.

As the exposed workpiece **146** in stacker **510** may be at different heights depending on the current capacity of stacker **510**, sensors or other monitoring devices may be used to signal a central controller which then calculates the proper amount for carrier **10**, **310** and support beam **36**, **350** to lower into tooling area **420** to properly engage the exposed workpiece **146**. Alternately, stacker **510** may include devices which automatically position the highest or exposed workpiece **146** at a predetermined and known height so that carrier lift **10**, **310** may be lowered to the same lowered position and engage workpiece **146** at a known height position. Other stacker devices **510**, constructions, orientations and operations known by those skilled in the art may be used.

Referring to FIG. **23**, an example application of carrier lift **10**, **310** in use with an exemplary transverse powered conveyor **528** is shown. In the example, a transverse powered conveyor **528** is positioned perpendicular or transverse to assembly line **316** path of travel **21**. The exemplary powered conveyor includes a pallet **532** which may include holding fixtures or other tooling to support and carry workpieces **146** in a known and predetermined position for assembly or manufacturing processing. Pallet **532** is preferably positioned on a powered roller frame transport **538**. In the example, the powered roller frame includes powered rollers which frictionally engage the pallets **532** to selectively propel the pallets **532** along a path of travel **540**, to and from, an area or workstation **314** beneath carrier **10**, **310** as generally shown. In the example, conveyor or shuttle **528** cycles to position a workpiece **146** into position below carrier **10**, **310** whereby carrier **10**, **310** and workpiece support beam **36**, **350** is lowered to engage the workpiece **146**, raise the engaged workpiece **146** and transfer the workpiece **146** to the next workstation **314** along path of travel **21** as previously generally described. A suitable example of a powered pallet and roller transport **532**, **538** is the VERSAPALLET® device by Comau LLC which is described in U.S. Pat. Nos. 6,966,427; 7,232,027 and/or 6,564,440 the entire contents of which are each incorporated herein by reference. Other conveyor devices and tooling change devices known by those skilled in the art may be used.

In one example, conveyor **528** operates as a "first-in-first-out" type of system where the workpieces **146** are kept in sequential order in the production assembly sequence. This is useful and advantageous to support the complex assembly build sequences in automotive assembly where, for example, random or short batch build sequences described above are used. The carrier lift **10**, **310** device is useful and fully supportive of this sequenced part or component delivery systems described in U.S. Pat. Nos. 8,869,370 and 9,513,625 the entire contents of which are incorporated herein by reference.

In another example of powered conveyor **528** (not shown), a second powered roller transport **528** and pallet **532** is used on the opposite side of carrier lift **10**, **310** (to the right of carrier **10**, **310** in FIG. **23**, not shown, workpieces shown in phantom line). In one example, the shown pallet and powered transport to the left and a pallet and conveyor to the right alternatingly cycle back and forth, to the right and the left, alternatingly providing selected workpieces **146**, for example **23**A-D to carrier **10**, **310**. In one example shown in FIG. **232**, if carrier lift **10**, **310** requires access/engagement with component **23**A, pallet **532** will move to the right positioning component **23**A within workstation **314** and into position to be engaged by carrier **10**, **310**.

In an alternate example, all of the workpieces **23** on the left transport conveyor **528** may be used or engaged and removed by carrier lift **10**, **310** before any from a right transport **528** (not shown) is employed and workpieces thereon used or processed. This may be useful in batch build assembly sequences where all of the components on one transport conveyor **528** are for one vehicle body type and another transport **528** may include workpieces **146** for an alternate vehicle type. Other combinations, constructions and orientations of transport conveyors **528** may be used as known by those skilled in the art.

As noted above, carrier lift **10**, **310** carriers **27**, **27**A, B and C and the variously described workstations **314** may include a plurality of sensor devices, for example, vision, optical, laser, pressure and limit-type switches, which all may be in communication with a local and/or central controller as described above in a closed loop, feedback system to continuously monitor, control and send data to and from the carrier **10**, **310**, so the carrier **10**, **310** and assembly line is highly monitored and controlled for present and historical operations data.

Referring to FIG. **25**, carrier lift **10**, **310** also includes the ability to adjust the pitch or distance **556** between workstation **314** centerlines **550** to properly position carrier **10**, **310** at the various workstations **314** along assembly line **316**. In one example, the pitch **556** is eight (8.0) meters (m) (26 feet) and the lift or travel range **560** of carrier **10**, **310** workpiece support beam **36**, **350** along axis of travel **370** is 1.5 meters (m) (5 feet). In one example, carrier **10**, **310** is capable of traveling the pitch distance **556** in five (5) seconds (s) or less and the lift **560** in three (3) seconds (s) or less. Other distances **556**, **560** and times may be used to suit the particular application and performance requirements as known by those skilled in the art.

Referring to FIGS. **26-30**, an alternate example of a transport carrier **310**A, carrier **27**D, and lift mechanism **352**B shown in FIGS. **17** and **18**A and B is illustrated. Referring to FIG. **26**, carrier **27**D is shown both in a raised **410** (shown in phantom lines) and a lowered **416** position, although it is understood that support beam **350** could not be in both positions at the same time in this example as shown for ease of illustration. The example carrier **27**D shown in FIGS. **26-30** is of the scissors-type **426** lift mechanism **352**B including first link **430** and second link **436** as generally described above for FIGS. **17** and **18**A and B. Alternate parts and assemblies may be different than examples described above as generally shown. A platform **346** (not shown) could also be used to suit the particular application and workpiece (s) **146** (not shown). In the example, the support member **30**, first link **430**, second link **436** are made from aluminum or steel including a plurality of apertures to maintain strength and reduce weight of the individual components and system **10**, **310** as a whole.

In the example shown in FIGS. **26-29**, alternate lifting mechanism **352**B is similar in construction and components, and the alternatives described therefore, as lifting mechanism **352**A as described above, for example motor **357**, ratchet mechanism **356**, motor **357**, drum **372** and tether **354** as illustrated in FIGS. **17-19**. It is understood that the example shown in FIGS. **26-30** could also take the form of the scissors **426**, including first link **430** and second link **436** oriented outward as shown in FIG. **19**.

As best seen in FIGS. **26**, **29** and **30**, carrier lift **310**A carrier **27**D includes a foot member **444** which connects to workpiece support member **350** at a lower end **445** and serves as a connection or anchor pivot point **440** for the second link **436**. In the example, foot **444** includes an opposing upper end **446** including a locating pin **447** as generally shown.

As best seen in FIGS. **27** and **28**, carrier **27**D includes a guide fork **448** connected to support member **30**. In the example, guide fork **448** defines a pair of aligned slots **449** that are sized and oriented to slidingly receive foot **448** locating pin **447** in the slot when the carrier **310**A support beam **350** is positioned in a raised position **410** as generally shown. Guide fork **448** provides the support beam **350**, and any workpiece **146** engaged therewith, added stability and control in the directions of the path of travel **21** and laterally when engaged, for example, during transfer of carrier lift **310** between workstations **314**. Other devices, constructions, positions and orientations of guide fork **448** may be used as known by those skilled in the art.

Referring to FIG. **27**, an example of previously described locking mechanism **132** is shown. In the example, locking mechanism **132**A includes a latch arm **134**A pivotally connected to guide fork **448**. In one example, latch arm **134** is positioned and oriented so that a distal end or hook can engage an aperture, or other feature, in foot **444** when in a lowered or latched position. As described above for locking mechanism **132**, when engaged with foot **444**, support beam **350** cannot be lowered along travel axis **370**. Alternate locking mechanism **132**A may be powered, controlled and monitored through actuators and/or sensors in communication with a local or central control system as described above. Other devices and alternatives described for locking mechanism **132** may be used for carrier **310** to suit the particular application and performance specification.

As best seen in FIGS. **27**, **29** and **30**, the exemplary carrier lift **310**A includes a pair of first guide members **494** extending longitudinally outward from opposing ends of the workpiece support beam **350**. The exemplary carrier lift further includes a pair of second guide members **496** fixed in position at the workstation. As best seen in FIGS. **29** and **30**, each second guide members **496** include a vertical guide channel **498** for sliding receipt of the respective first guide member **494** when the carrier is positioned in the lowered position **416** as shown in FIGS. **26**, **29** and **30**. In the lowered position, engagement of the first guide member **494** with second guide member **496** locates and securely positions the workpiece support beam **350** and supported workpiece **146** (not shown) in a desired or predetermined position when in the workstation.

Referring to FIG. **31**, an example of a method **600** for raising and lowering a workpiece **146** in a workstation using a carrier lift **10**, **310** is illustrated. In an example and optional first step **610**, examples of the above-described carrier lift **10**, **310** including exemplary trolley **28** and carrier **27**, **27**A, B, C or D supporting a workpiece **146** are transferred to a predetermined workstation. As described, the trolley **28** may, as an example, be engaged with an elevated or overhead conveyor **20** that selectively moves along an assembly line path of travel **21** through one or more workstations or predetermined areas along the assembly line. In one example, the assembly line path of travel **21** includes a plurality of sequentially positioned workstations or assembly cells, for example workstations **314**, where one or more assembly or manufacturing operations are conducted on a component or subassembly serving as the workpiece **146**.

It further understood that the workstation could be a non-assembly or non-manufacturing cell or area, for example a stacker or buffer **510** device, work table **508**, or area where workpieces **146** are temporarily stored in fixtures or racks until the workpieces are re-engaged by the carrier **27**, **27**A-D for further processing or transfer along the assembly line or to another predetermined location or area. For example, the workstation may be a production line buffer wherein workpieces that are in process are temporarily stored or racked, for example cradle **516** in FIG. **22**, until needed for the next stage of the assembly or manufacturing process. For example, if there is stoppage along one portion of an assembly line downstream, the upstream or prior assembly process may continue and the workpieces temporarily stored in a buffer rack **516** or area until the downstream process can accept them for further processing. Alternately, the device **10**, **310** and process **600** may deliver and lower the workpieces **146** as described in storage racks for longer storage, for example, completed workpieces to be packaged and shipped. Other workstations, processes and applications for carrier lifts **10**, **310** and system **600** known by those skilled in the art may be used.

In an exemplary second step **620** a carrier **27**, **27**A-D supporting the workpiece **146** is selectively lowered from a raised position to a lowered position in the workstation. In an optional step **625**, the carrier positions the workpiece **146** in a fixture, tooling, rack or other device positioned in the workstation, for example trunnion fixture **148**, work table **508**, cradle **516**, or tooling **534**, used to support and/or manipulate the workpiece **146** as needed for the predetermined process or processes in the workstation. It is understood that the carrier can be lowered (or raised) and stopped at any point along the carrier vertical axis of travel **370** suitable for the particular workstation or process. In one example (not shown), the carrier **27**, **27**A-D automatically disengages or releases the workpiece **146** from a workpiece support beam **36**, **350** through actuation of one or more workpiece engaging devices **147** connected to the support beam **36**, **350** as described above. It is understood that carrier **37**, **27**A-D may begin at a lowered position and raised to the raised position for further processing.

In one example (not shown) the carrier **27**, **27**A-D is raised from the lower position away from the exemplary fixture or other device supporting the workpiece to provide clearance for the predetermined process or operation to take place on the workpiece.

In one exemplary step (not shown), a buffer **510**, cradle **516** (FIG. **22**) may be indexed to expose a supported workpiece **146** along the carrier **27**, **27**A-D travel axis **370**, such that support beam **36**, **350** may engage the workpiece and transfer the workpiece to another workstation. In another example (not shown), tooling **534** on a shuttle **520** (FIG. **23**) may be indexed into a workstation to expose the workpiece for engagement by support beam **36**, **350**.

In the example, step **630** includes conducting a process on the workpiece. The process or operation may be, for example, welding, brazing, soldering, application of adhesive, riveting, staking, bolting, drilling, machining, polishing and other assembly and/or manufacturing processes, or temporary storage for example in a buffer, known by those skilled in the art (each considered a process or operation as used herein). These processes may be executed by programmable industrial robots (not shown) or other automated or semi-automated devices or manual by an operator.

In an optional step **635** (not shown), opposite to optional step **625**, the carrier **27**, **27**A-C may remove the workpiece **146** from the fixture or other workpiece supporting device. In one example (not shown) described above, the carrier **27**, **27**A-D will automatically actuate workpiece engaging devices **147** to re-engage or reacquire the workpiece **146** to support beam **36**, **350** so that the carrier again supports the workpiece **146**. Sensors may be used along with power sources to determine the position of the support beam **36**, **350** relative to workpiece **146** in order to actuate the workpiece engaging devices **147** to re-engage or removably connect the support beam **36**, **350** to the workpiece **146**. It is understood that, depending on the application and assembly process, steps **625** and **635** can be switched. For example, step **625** can be that carrier lift **10**, **310** first goes to, for example, a stacker or buffer **510**, or a worktable **508**, where the workpieces **146** are presently positioned and first engage the workpieces and then removing them (versus carrying workpieces **146** into the workstation and depositing them as first described for step **625** above).

In example step **640**, the carrier **27**, **27**A-D raises the workpiece **146** from the lowered position, for example **416**, to a raised position, for example **410**, in the workstation. In one step (not shown) a locking mechanism **132**, **132**A may be actuated to lock or prevent vertical movement of the carrier **27**, **27**A-D support beam **36**, **350** while in a locked position.

In an optional and exemplary step **655**, the carrier lift **10**, **310** is transferred from the workstation along the assembly line path of travel **21** to the next predetermined workstation or location for further processing or storage. It is understood that the above steps are exemplary and that additional, or fewer, steps, and in different order of sequence, may be used in the manners described above without deviating from the present invention. In one example step not shown, the workstation may include two sequential workstations, for example workstations **314**A and B (FIG. **20**). One of the workstations **314**A and B may include a manual workstation and the other may include an automated or semi-automated workstation as described above relating to FIG. **20**. The carrier **27**, **27**A-D may move back and forth between the workstations **314**A and B as needed depending on the assembly process.

All terms used in the claims are intended to be given their broadest reasonable constructions and their ordinary meanings as understood by those skilled in the art unless an explicit indication to the contrary is made herein. In particular, use of the singular articles such as "a," "the," "said," etc. should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary.

The above drawings are not necessarily to scale and certain features may be exaggerated, removed, or partially sectioned to better illustrate and explain the present invention. Further, the above descriptions set forth herein are not intended to be exhaustive or otherwise limit or restrict the claims to the precise forms and configurations shown in the drawings and disclosed in the following detailed description.

The foregoing description relates to what is presently considered to be the most practical embodiment. It is to be understood, however, that the invention is not to be limited to the disclosed embodiments but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as is permitted under the law.

It is to be understood that the above description is intended to be illustrative and not restrictive. Many embodiments and applications other than the examples provided would be apparent to those of skill in the art upon reading the above description. The scope of the invention should be determined, not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. It is anticipated and intended that future developments will occur in the arts discussed herein, and that the disclosed systems and methods will be incorporated into such future embodiments. In sum, it should be understood that the invention is capable of modification and variation and is limited only by the following claims.

What is claimed is:

1. A method for manipulating the position of a workpiece in a workstation, the method comprising:

transferring a trolley engaged with a conveyor along a path of travel to a predetermined position at a workstation, the trolley connected to a carrier having a workpiece support beam operable to support a workpiece, the carrier further including a scissors device comprising:

a pair of first links pivotally connected to the trolley about respective first axis of rotation, the pair of first links positioned apart along the workpiece support beam;

a pair of second links, each second link pivotally connected to a respective first link about respective second axis of rotation parallel to the first links first axis of rotation, each of the second links pivotally connected to the workpiece support beam, the scissors device operable to contract and extend in a length along the carrier axis of travel;

lowering the carrier relative to the trolley by a lifting mechanism from a raised position to a lowered position along a carrier axis of travel in the workstation thereby extending the scissors device;

conducting a process on the workpiece;

raising the carrier from the lowered position to the raised position in the workstation by the lifting mechanism thereby contracting the scissors device; and

transferring the trolley from the predetermined position at the workstation by the conveyor along the path of travel.

2. The method of claim **1** further comprising:

connecting a tether to the workpiece support beam;

engaging the tether with a rotatable drum mounted to the trolley; and

energizing a motor engaged with the drum to selectively rotate the drum to spool a length of the tether onto the drum raising the workpiece support beam relative to the trolley or unspool the length of the tether from the drum lowering the workpiece support beam relative to the trolley along the carrier axis of travel.

3. The method of claim **1** wherein the carrier further includes a first guide member positioned on the workpiece support beam and the workstation includes a second guide member stationarily positioned in alignment with the first guide member, the method comprising:

engaging the first guide member with the second guide member on lowering the carrier to the lowered position to position the workpiece support member in a predetermined position in the workstation.

4. The method of claim **1** wherein the trolley includes a pair of forks and the workpiece support beam including a pair of foot members each including a locating pin in alignment with the trolley forks along the carrier axis of travel, the method comprising:

engaging each foot locating pin with a respective trolley fork when the carrier is in the raised position to secure the workpiece support beam in the carrier raised position.

5. A method for manipulating the position of a workpiece in a workstation, the method comprising:

transferring a trolley engaged with a conveyor along a path of travel to a predetermined position at a workstation, the trolley connected to a carrier having a workpiece support beam operable to support a workpiece;

connecting a tether to the workpiece support beam;

engaging the tether with a rotatable drum mounted to the trolley;

engaging a motor stationarily mounted in the workstation with a ratchet coupler connected to the drum when the carrier is positioned at the predetermined position at the workstation;

energizing and selectively rotating the motor engaged with the ratchet coupler to selectively rotate the drum to unspool a length of the tether from the drum lowering the workpiece support beam relative to the trolley by a lifting mechanism from a raised position to a lowered position along a carrier axis of travel in the workstation;

conducting a process on the workpiece;

energizing and selectively rotating the motor engaged with the ratchet coupler to selectively rotate the drum to spool the length of the tether onto the drum raising the workpiece support beam from the lowered position to the raised position in the workstation by the lifting mechanism; and

transferring the trolley from the predetermined position at the workstation by the conveyor along the path of travel.

6. A method for manipulating the position of a workpiece in a workstation, the method comprising:

transferring a trolley engaged with a conveyor along a path of travel to a predetermined position at a workstation, the trolley connected to a carrier comprising one of a scissors device or a telescopic post device connected trolley and having a workpiece support beam operable to support a workpiece;

disengaging a locking mechanism from one of a foot connected to the workpiece support beam or the telescopic post device permitting the lowering of the carrier from a raised position to the lowered position;

lowering the carrier relative to the trolley by a lifting mechanism from the raised position to the lowered position along a carrier axis of travel in the workstation thereby extending respective one of the scissors device or the telescopic post device;

conducting a process on the workpiece;

raising the carrier from the lowered position to the raised position in the workstation by the lifting mechanism thereby contracting respective one of the scissors device or the telescopic post device; and

transferring the trolley from the predetermined position at the workstation by the conveyor along the path of travel.

7. A method for manipulating the position of a workpiece in a workstation, the method comprising:

transferring a trolley engaged with a conveyor along a path of travel to a predetermined position at a workstation, the trolley connected to a carrier having a workpiece support beam operable to support a workpiece, the carrier further comprising a workpiece engaging device connected to the workpiece support beam operable to selectively engage the workpiece;

lowering the carrier relative to the trolley by a lifting mechanism from a raised position to a lowered position along a carrier axis of travel in the workstation;

one of disengaging or engaging the workpiece by the workpiece engaging device while the workpiece support beam is positioned at the lowered position in the workstation;

conducting a process on the workpiece;

raising the carrier from the lowered position to the raised position in the workstation by the lifting mechanism; and

transferring the trolley from the predetermined position at the workstation by the conveyor along the path of travel.

8. The method of claim **7** wherein the workstation includes a stationary power source positioned along the carrier axis of travel and the workpiece support beam includes a complimentary power connector in electric communication with the workpiece engaging device, the method further comprising:

automatically engaging the workpiece support beam power connector to the stationary power source when the carrier is positioned in the lowered position;

providing electric power to the workpiece engaging device to selectively actuate the workpiece engaging device to engage or disengage the workpiece.

9. The method of claim **7** further comprising the steps of:

engaging the workpiece with a fixture positioned in the workstation at the carrier lowered position;

disengaging the workpiece from the workpiece support beam by the workpiece engaging device prior to conducting the process on the workpiece; and

re-engaging the workpiece to the workpiece support beam by the workpiece engaging device following conducting the process on the workpiece.

10. The method of claim **9** wherein the fixture positioned in the workstation comprises a trunnion fixture, the step of conducting a process on the workpiece further comprises:

rotating the trunnion fixture and the engaged workpiece about a trunnion fixture axis of rotation to a predetermined rotated position for the workpiece.

11. The method of claim **7** wherein the workstation comprises one of a buffer or a cradle, the method further comprising the steps of:

indexing the buffer or the cradle to expose the workpiece for engagement of the workpiece by the workpiece engaging device;

lowering the workpiece support beam to the lowered position by the lifting mechanism;

engaging the workpiece to the workpiece support beam by the workpiece engaging device; and

removing the workpiece from the buffer or cradle by raising the workpiece support beam by the lifting mechanism.

12. The method of claim **7** wherein the workstation comprises a workpiece shuttle positioned transverse to the path of travel, the method further comprising the step of:

indexing the workpiece shuttle to expose the workpiece for engagement of the workpiece by the workpiece engaging device;

lowering the workpiece support beam to the lowered position by the lifting mechanism;

engaging the workpiece to the workpiece support beam by the workpiece engaging device; and

removing the workpiece from the workpiece shuttle by raising the workpiece support beam by the lifting mechanism.

13. A method for manipulating the position of a workpiece in a workstation, the method comprising:

transferring a trolley engaged with a conveyor along a path of travel to a predetermined position at a workstation, the trolley connected to a carrier comprising a workpiece support beam operable to support a workpiece, the carrier further comprising a pair of telescopic post devices positioned apart along the workpiece support beam, each telescopic post device connected to the trolley and the workpiece support beam;

lowering the carrier relative to the trolley by a lifting mechanism from a raised position to a lowered position along a carrier axis of travel in the workstation thereby extending the telescopic post device;

conducting a process on the workpiece;

raising the carrier from the lowered position to the raised position in the workstation by the lifting mechanism thereby contracting the telescopic post device; and

transferring the trolley from the predetermined position at the workstation by the conveyor along the path of travel.

14. The method of claim **13** wherein the carrier further includes a workpiece engaging device connected to the workpiece support beam operable to selectively engage the workpiece, the method further comprising the steps of:

one of disengaging or engaging the workpiece by the workpiece engaging device while the workpiece support beam is positioned at the lowered position in the workstation.

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